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MORPHOLOGY OF THE PALMAR HYPOTHENAR DERMATOGLYPHICS IN MAN

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INTRODUCTION

DANFORTH ('30) opens his study of numerical variation and homologies of vertebrae with the remark that "a great deal of morphological discussion is pervaded by a general concept which might be characterized as belief in the individuality, almost *personality,* of anatomical parts." While the comment was doubtless intended to bear particularly on interpretations of vertebral morphology, it is equally pertinent within the field of dermatoglyphics. Dermatoglyphic patterns[1] are frequently credited, either expressly or tacitly, with what may be termed individuality. This attribution expresses itself in the consideration of patterns as if they were determined and transmitted both along phylogenetic and familial descent by some autonomous germinal agency, and independent of an epigenetic pattern-conditioning mechanism.

[1] Throughout this paper the term *pattern* is used in its strict sense, applying to discrete local systems of ridges—whorls, loops and the like—as contrasted with patternless *open fields,* which lack abrupt ridge curvatures. The distinction is illustrated in fig. 1, a palm bearing four patterns (three interdigitals and hypothenar); these patterns are conspicuous areas of abruptly curved ridges, while the greater part of the palm is patternless. The term *configuration* is a general designation embracing all forms of ridge arrangement.

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The sense of individuality enters into the discussion of relations of the varying pattern types. The affinities of morphologically different configurations occurring in a particular dermatoglyphic territory are commonly explained in terms of conversion, one type being transformed into another through rearrangement of the component ridges (though of course not implying that an individual pattern, once formed, can be so altered). It must be admitted that an intergrading series of patterns may be assembled to illustrate a sequence of "transformations." The familiar concentric whorl may be placed at the beginning of a series (or at the end, in a conflicting interpretation of the direction of evolution of the pattern types); the whorl is *transformed* into a loop figure, and the loop in turn is *transformed* into an arch. This treatment of the relationships of patterns claims a rightful place in morphological discussion, but whether its rôle is explanatory or merely descriptive is the question here under consideration. To anticipate, it may be stated that the morphological interpretations now presented are from the view of observations by Kollman ('83), Bonnevie ('24-'32) and Cummins ('26) on the ontogeny of dermatoglyphics. The interpretations of pattern morphology on this basis deprive the pattern of such individuality as has been mentioned above. If the interpretations are correct a pattern owes its existence, as well as configurational type, to epigenetic circumstances alone.

Any one of the patterns of the digits, palm or sole might have been selected in illustration of the morphological principles which are to be discussed in specific application to the palmar hypothenar. Apical patterns, having received special attention and being collected in numbers for personal identification, offer the advantage of a rich material already available to show the possibilities of pattern variation. The discussion will be doubly profitable, however, if it is based on some pattern which is less well known, a survey of its variations being a necessary provision. In this connection it may be mentioned that various previously unrecognized types of hypothenar configurations are now illustrated in the accompanying plates, and that incidences are recorded for all the types encountered in a series numbering over 2800 palms.

During the past several years the writer has been collecting material for an analysis of the plantar hypothenar configuration, his attention having been directed to certain puzzling aspects of its morphology (see Wilder, '16, pp. 157-171). In the meantime several considerations have brought the palmar hypothenar into the foreground as an object

of study. It may be mentioned especially that in the preparation of revised methods for the formulation of palmar dermatoglyphics (Cummins *et al.*, '29) it was soon evident that the scheme of formulation could be best founded on descriptive characters solely, so as to free the working method of debatable morphological issues concerning affinities of the variant configurations. In the course of that work the writer had been impressed by certain points of morphology in connection with the palmar hypothenar, and determined to inquire more fully into these questions.

While the present account deals with morphological principles in specific reference to the palmar hypothenar it is believed that the generalizations are equally pertinent to other configurations. Attention may be directed to the fact that the principles here set forth, embodying a departure from the prevailing approach to pattern morphology, provide a solution to the identities of certain types of hypothenar patterns incompatible with the evolutionary sequence proposed by Wilder ('26).

The setting for the inquiry may be outlined by brief reference to some of the general characteristics of the dermatoglyphs and their correlation with the volar pads (walking pads; Tastballen). Through comparative studies, notably that of Whipple ('04), it is clear that the volar pads conform in their number and arrangement to a type plan. In pentadactylous mammals there are characteristically eleven volar pads on each member: five apical pads, situated on terminal segments of the digits; a series of four interdigital pads, opposite the interdigital intervals in the distal zone of the palm or sole; two pads located in the proximal region of the palm or sole, the thenar and hypothenar. The pads are not equally prominent in all mammals, nor are all the pads in one individual of a species developed to the same degree. Notwithstanding such variations, together with the occasional failure of pads, the occurrence of pads additional to the typical series and of fusions of adjoining pads, there is in general a recognizable conformity to the schema of pad arrangement.

The integument clothing the volar surfaces is specialized, distinguished among other features by its ridged character. The epidermal ridges (cristae, papillary ridges, friction ridges, Tastlinien) are disposed in territories of distinctive configuration, certain areas often exhibiting concentric, looped and other designs, called patterns. Such designs figure the surfaces of the pads of the typical series as characterized above, each pattern having the name of the pad which it covers, though they may occur also on accessory pads or even in valleys of the volar

reliefs. The patterns themselves present great variety. Corresponding patterns are individually variable in the same species and the several patterns of the typical series commonly exhibit differences, not only in different species but in one individual.

A comparative survey is naturally requisite in the analysis of pads, and to the degree that patterns are associated with pads in the expression of their morphological plan the dermatoglyphs likewise demand a broad view of the mammalian series. The writer, however, has chosen to emphasize the hypothenar configuration in a single species, man, drawing upon the comparative observations only to the extent just indicated. The restriction should not be misunderstood as an intention to minimize the importance of comparative dermatoglyphics in the analysis of this or any other pattern. Nor should it be taken to mean that the writer has neglected to consider the comparative material in its relation to the present inquiry.[2] It may be stated that the ontogenetic viewpoint in dermatoglyphic morphology, here presented with a single human pattern serving as illustration, is believed to be consistently applicable to other patterns in man and to the configurations of Primates generally.

TOPOGRAPHY OF THE HYPOTHENAR CONFIGURATIONS

The hypothenar configuration, in the broad sense, may be defined as the configuration associated with the rolling contour of the hypothenar eminence. This muscular eminence, as emphasized by Whipple, is not to be confused with the volar pad which surmounts it. The hypothenar pad, one of the primary series of volar pads, is an important localizing feature of the hypothenar configuration, *sensu stricto*. Configurational characters associated with the pad are exhibited as patterns and irregularities of patternless configurations, locally disarranging the otherwise fairly consistent ridge disposition over the hypothenar

[2] I am indebted to Dr. Charles Midlo for the loan of a large series of unpublished dermatoglyphic drawings worked out in the extensive Primate Collection of Dr. A. H. Schultz. These drawings enlarge materially the data bearing on variation in primates, and for examination of the hypothenar they have served as a useful supplement to figures and descriptions available in the literature, mainly appearing in the publications of Kidd, Whipple, Schlaginhaufen and Bychowska. While the present account does not discuss the comparative aspects of hypothenar morphology it should be stated that control from this standpoint has been applied, with the conclusion that the treatment here followed introduces no inconsistencies with findings in forms other than man.

eminence. In order to obviate confusion between the two applications of the term "hypothenar configuration," and at the same time to avoid the constant repetition of qualifying expressions, two distinctive terms are employed hereafter. The term *primary hypothenar* is applied to configurations associated with hypothenar pads, and *hypothenar system* is used to designate the configuration of the hypothenar eminence, both for the configuration of the whole eminence when primary hypothenar configurations are lacking and, when primary configurations occur, to areas unoccupied by them.[3]

In the postnatal human subject the volar pads are obscure, contrasting with the conspicuous elevations occurring in many mammals and even in the human embryo during a limited period. The proximal portion of the hypothenar eminence, viewed in ulnar profile, often shows, however, one or sometimes two local bulges representing the reduced proximal hypothenar pad. Wilder ('25) illustrates such a view of his own right hand, the mound of the pad having in this instance a single summit.

The pads of the embryo are of direct assistance in defining the topography of the various dermatoglyphic elements. The embryonic pads are discretely outlined during their early history, and they are relatively more elevated than in the later fetal and post-natal period. The morphological plan of the dermatoglyphs is dependent upon the disposition of the pads, and as detailed below, the existence of a pattern and the character of its configuration are conditioned by the subjacent pad. It is thus necessary to turn to the hypothenar pad of the embryo, concerning which reference may be made to observations reported by the present writer ('29).

Recalling the distinction drawn by Whipple between primary and secondary pads, it will be evident that the eleven pads enumerated above

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[3] Since these two terms have not been employed hitherto a further explanation may be in order. In choosing the term "*primary* hypothenar configuration" the intent is to emphasize that the configuration is actually primal; in phylogeny ridges are first developed over pads, and in ontogeny, as shown by Bonnevie in the instance of apical configurations, pads are precocious in the differentiation of ridges. The sense of "system" is introduced in the second term for the reason that the configuration is an assemblage of ridges having an orderly relation to the hypothenar eminence, and further, that the assemblage is morphologically composite, showing in over two-thirds of the palms here reported an incorporation of areas which are morphologically primary (sites of suppressed pads) into the generalized open-field configuration of the eminence.

constitute the primary series, being pads which conform in their placement to the typical plan. The secondary pads are regarded by Whipple as secondary accessions to the pad series, arising as adaptations to the functions of highly specialized hands and feet. Such supernumerary pads are inconstant in occurrence in the mammalian series. They are distinguished by the positions which they occupy; a pad situated on the proximal phalanx of a digit, or a pad lying within a digitovolar furrow is thus immediately identified as an element foreign to the system of primary pads.

It appears that all embryos are initially provided with the full series of primary pads. The most instructive period in which to observe them, from the standpoint of morphology, is prior to the attainment of a CR length of about 40 mm., for during their later history the pads become less discrete, subsiding and even undergoing total effacement. The hypothenar pad is early divided into a small distal component, lying adjacent to the fourth interdigital pad, and a more elongated proximal component occupying the remainder of the hypothenar region. Individual variations in the contour of the latter are evident as development proceeds, notably in the position of its most elevated region and in the occasional occurrence of more than one summit.

The purpose of this mention of the history of the hypothenar pad is two-fold. First, the pad is the background of the primary hypothenar configurations, and hence should be of service in defining the extent of the dermatoglyphics which are comprised in that designation. The second aim concerns the developmental conditioning of the configurations, a matter reserved for treatment in the discussion.

Turning now to the pad as a background for the primary hypothenar configurations, attention should be directed to its division into distal and proximal components. Do the dermatoglyphics exhibit any evidence of a duality which may be associated with this separation of the pad? Such evidence must be sought in the occurrence of patterns, for when the entire hypothenar eminence displays a continuous open-field configuration (hypothenar system, formulated, O or A^u) there is no dermatoglyphic indication of pad or boundaries. While one may find numerous examples of patterns occupying the proximal component of the hypothenar pad, a pattern lying on the distal component is a rarity. In several thousands of palms (in the Wilder Collection and my own files) there is but a single example of a pattern which may be so identified. It came to light in the course of the survey of hypothenar

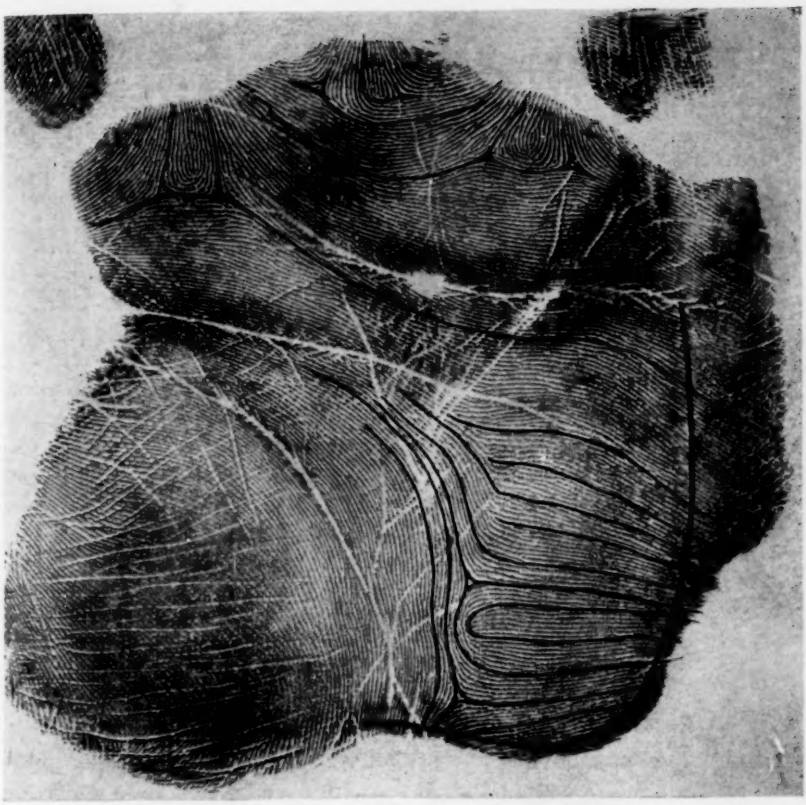


FIG. 1. A PALM PRINT ILLUSTRATING THE DISTINCTION BETWEEN PATTERNS AND PATTERNLESS CONFIGURATIONS

All four patterns occurring in this palm are loop designs; they are the second, third and fourth interdigital patterns (neighboring the corresponding interdigital intervals) and the primary hypothenar (in the proximal region of the hypothenar eminence). The tracings in the hypothenar region and the heavy marginal line exemplify the original form of the tracings reproduced in figs. 4-148.

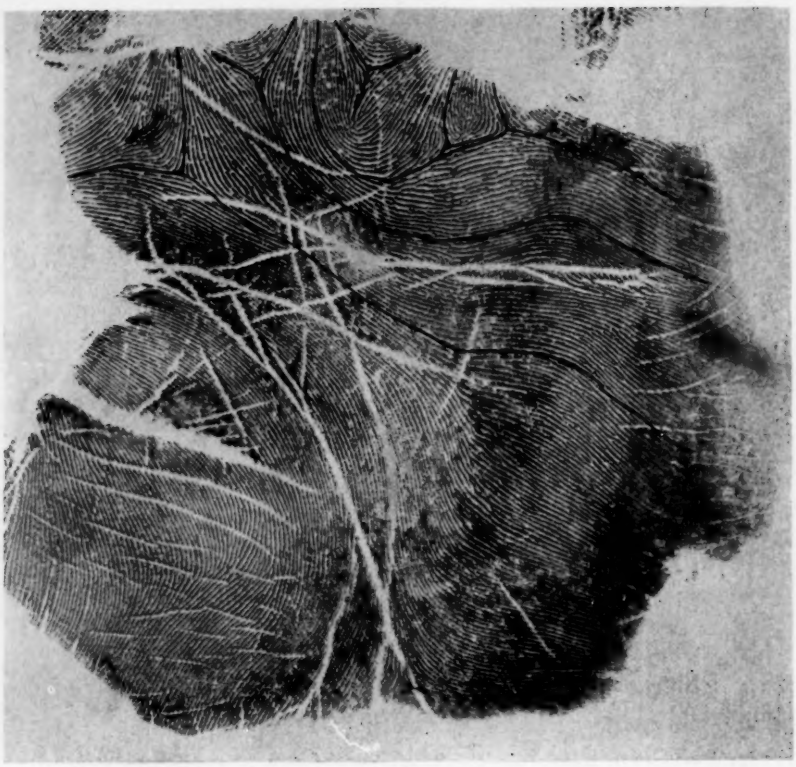


FIG. 2. A PALM PRINT ILLUSTRATING THE CONTINUOUS OPEN-FIELD CONFIGURATION OF THE HYPOTHENAR SYSTEM IN THE ABSENCE OF PRIMARY HYPOTHENAR PATTERNS

configurations which was carried out in the preparation of the revised methods of formulation.

Mrs. Wilder made a sketch of the palm print, submitting it to the collaborators as a sample of a pattern refractory to the system of formulation then under consideration. Since it was decided to avoid encumbering the formulation with provision for rare variants, the pattern was dismissed without further ado. The writer had filed Mrs. Wilder's drawing, and with this acknowledgment of its origin the configuration may be now brought into the discussion of hypothenar morphology.

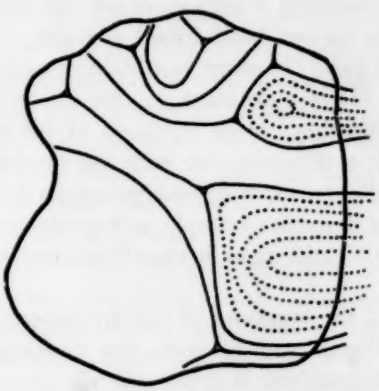


FIG. 3. A COMPOSITE TRACING SHOWING BOTH DISTAL AND PROXIMAL PRIMARY HYPOTHENAR PATTERNS

The distal pattern is a unique rarity; the palm bearing it is here reproduced with the addition of a proximal pattern from another individual, so as to emphasize the duplex nature of the primary hypothenar configuration.

Figure 3 represents a copy of this singular palm, modified by the addition of a fairly common form of primary hypothenar pattern (L^u). This addition was made because the palm lacked a true pattern in the proximal portion of the hypothenar region, the configuration in the original being of the A^u type. The insertion of a pattern is a legitimate modification, for this feature and the curious pattern in the distal region might well be found actually in the same hand, and any of the varieties might have been selected instead of L^u. The addition of an expansive hypothenar pattern provides an instructive illustration of the duplex nature of the hypothenar pad. It has been pointed out that the

volar pads are the conditioning factors in the development of patterns of the morphological series. Now if we recall the history of the palmar hypothenar pad, with its representation by a smaller distal component and a larger proximal component, it will be clear that the configuration shown in Fig. 3 is a correlate of the duplex pad condition. The pattern lying below the base of the minimus is regarded as the distal element of the primary hypothenar configuration, while the large L^u pattern is the proximal element. Between the two patterned areas there is a featureless open field, representing a section of the hypothenar system. Inasmuch as the distal region here found carrying a pattern is almost universally an open field (in other words, incorporated into the hypothenar system), the interest attached to the whole distal area is satisfied with its identification as the territory of the primary hypothenar configuration. It is a different case with the proximal territory, where there are the most diverse types of configurations (Figs. 4-148). While these commonly are designated simply as hypothenar configurations, the foregoing comment should make it clear that they represent merely the proximal element.

Having in mind the contours of the hypothenar eminence and the surmounting hypothenar pad or pads, the dermatoglyphics associated with them are to be examined in greater detail.

Practically every palm exhibits ridge arrangements which render distinctive the configuration of the hypothenar eminence. But in order that these ridge arrangements may be observed in their simplest expression, undisturbed by coexisting primary hypothenar patterns, a palm presenting such a configuration should be selected for first inspection. It will be seen that the hypothenar eminence is figured by ridges having distinct curvatures, as shown in Fig. 2. The palm print here illustrated is not technically perfect, but its imperfection happens to be instructive, in that through excessive pressure the region of the hypothenar eminence is rendered darker in the print. The configuration in this darker area, representing the hypothenar system, is distinguished by its arciform ridges. The arciform system, while variable in its details in different palms, is believed by the writer to be causally associated with the rolling contour of the hypothenar eminence. It represents, therefore, a unit of the dermatoglyphs which is as deserving of a morphological rank as are the patterns associated with pads. The characteristics of this hypothenar system may be recognized even when there occur primary hypothenar patterns, its sections being evident in the area not covered by patterns.

It is impossible to establish precisely a peripheral limit of the hypothenar system excepting along the ulnar margin of the hand, where it is indicated by the extent of ridged skin, ridges being discontinued ordinarily at a level about half way to the dorsum. On the radial side an approximate boundary may be drawn by a line connecting the base of the ring-finger with position 2 of the standard formulation (an axial triradius situated at or near the proximal margin of the palm, or a "parting" of ridges in the same position, or in the absence of either, the indentation of the print marking the separation of the thenar and hypothenar eminences). Proximally, in the wrist region, there usually occurs a discrete bracelet system of ridges, coursing transversely in this territory proximal to the transverse radiants of the proximal axial triradius; in the presence of this system the proximal limit of the hypothenar system is its conjunction with the bracelet system, as indicated by the axial triradius (formulated, t) and its radiant extending ulnarward. There is often, however, no dermatoglyphic landmark of the proximal boundary of the hypothenar system, being in effect as if the bracelet system extended distally into the known territory of the hypothenar (accompanying distal migration of the axial triradii to positions denoted in the formulation as t′) or as if the hypothenar system had absorbed the bracelet system (its ridges, deviated from the transverse alignment, extended into the known territory of the bracelet system).

There is no reliable dermatoglyphic landmark by which to identify the limits of the morphological territory of the primary hypothenar configuration, marking separation from the hypothenar system in which it lies. It is true that by definition a true pattern situated on the hypothenar eminence is at once recognized as a primary configuration, but as will be shown below it is not always clear that the pattern occupies an area corresponding to the potential extent of a primary pattern, as measured by the expanse of the embryonic pad. A suggestion of such limits is present in an occasional palm, in which a central axial triradius (t″) is so situated that its ulnarward radiant appears to form a natural distal boundary line (e.g., figs. 64, 81, 84). Though the boundary thus indicated appears to coincide with the relative distal extent of the embryonic proximal hypothenar pad, a triradius associated with the pattern is no dependable landmark, as shown by its fluctuations in different palms. In the sequence of figs. 64 to 73, for example, it will be observed that the varying positions of the triradius are associated with variations in expanse of the pattern. Thus, even when this feature

does appear to form a natural boundary of the primary hypothenar (fig. 64), it must be noted that a triradius situated much farther proximally, as in fig. 69, is an equally distinct *boundary of a pattern*; in the latter case it is clear that the distal boundary of the pattern is *not* the distal boundary of the morphological primary hypothenar area, for it does not limit an expanse sufficiently large to correspond to the extent of the embryonic pad. A comparison of figs. 85 and 90 may help to make this point more clear, as well as to illustrate that other boundaries of primary patterns share with the distal one this failure to express the full pattern-conditioning potentiality of the pad. It is plainly evident that the diminutive whorl shown in fig. 90, while designated the primary hypothenar configuration, represents but a small share of the *morphological* proximal primary hypothenar area. The finding is interpreted to mean that the embryonic pad in this individual had regressed further (than in the individual shown in fig. 85, for example) by the time of ridge differentiation. With involution of the pad the configuration of all but a small portion of its morphological territory is made a part of the hypothenar system, and with complete regression the hypothenar system shows no vestige of the former existence of a pad (fig. 4 for example).

In summary of the observations above:

1. The configuration of the hypothenar eminence as a whole is entitled to morphological recognition, representing as it does a territory of the palmar dermatoglyphics in which characteristic ridge alignments are correlated with the modeling of the eminence. It may be designated the hypothenar system.

2. The hypothenar eminence bears the hypothenar pads, which are best seen in the embryonic period. The pads may condition the appearance of patterns—whorls, loops and other figures. One hypothenar pad develops over the distal portion of the hypothenar eminence; but a single case is known in which a pattern appears on its site, the configuration being with this exception an open field with arciform ridges. The main hypothenar pad appears as a local rise, sometimes with more than one summit, situated on the proximal region of the eminence; this is very commonly the site of a pattern. Patterns borne by these pads are primary hypothenar configurations. The expanse of the pads, in the state of their maximum development in the embryo, is the ultimate criterion of the morphological rank of regions of the primary hypothenar configuration. When the patterns are most extensive they appear to cover

areas relative to entire sites of the embryonic pads. With complete suppression of patterns the corresponding open-field areas are merged into the hypothenar system, as is true of the open fields which adjoin patterns of reduced size.

DESCRIPTION

The configuration which is usually designated the hypothenar embraces only the proximal region of the hypothenar eminence. Employing the most expansive patterns as an indication of its extent, this portion covers roughly the proximo-ulnar quadrant of the palm. It is with this portion only that the following descriptive section is concerned.

Hypothenar configurations have been examined in 2827 palms (1420 rights; 1407 lefts), selected at random from the writer's file of prints. No attempt is made to separate the individuals by race or by sex, but in the table of incidences the configuration types are recorded separately for right and left hands. The following procedure was adopted in compiling the configuration varieties. As each palm print first in the series was examined, a tracing of the hypothenar configuration was made on transparent paper, and on a tally sheet a notation was entered to indicate the character of the configuration, the customary symbols being employed for this purpose. Very early in the sequence of prints, naturally, configurations essentially duplicating examples previously traced were encountered. Having the drawings spread out temporarily pasted on large sheets, it was readily determined whether a configuration under examination differed in any significant respect from those already traced. The series of tracings being designed merely as a record of representative forms, it was necessary only to make entries in the tally sheet for configurations conforming to those already included in the tracings. In all, 145 tracings were assembled, and these are here reproduced, (figs. 4-148), forming a pictorial record of the variable configurations. For convenience of comparison the tracings of left palms were reversed in the preparation of the final drawings, so that all the hypothenars appear as on prints of right hands. The thin lines represent actual tracings of ridges on the prints, the traced ridges being selected at intervals close enough to illustrate the essential character of the configurations, as shown in fig. 1. The heavy line bordering each drawing represents the palmar margin, and is added as a guide to the orientation of the dermatoglyphic features on the palm. The distal extremity of this heavy line uniformly marks the point at which the distal transverse flexion furrow reaches the ulnar border of the palm.

In introduction to this descriptive section reference should be made to Wilder's paper ('26), "The morphology of the hypothenar of the hand; a study in the variation and degeneration of a typical pattern." Pointing out that the primitive state of the pattern is a whorl configuration (a concentric design, W, figs. 84-93), he derives all other varieties of configuration from it, tracing the sequence of variations along several lines of development, depending upon the disappearance of one or another of the three triradii which bound the typical whorl. Thus, all the simple loop patterns (L^r, figs. 28-48; L^u, figs. 64-80; L^c, figs. 49-57) arise through the suppression of a single one of the three triradii, the loop "opening" in the direction of this missing element. Figures known as simple arches (A^u, figs. 4-7; A^c, fig. 11; A^r, figs. 12-14) arise in consequence of the suppression of two triradii, the concavity of the arch in each case facing the sites of the missing triradii. In this manner Wilder differentiates seven *primary types* of hypothenar configurations: the typical whorl, three varieties of loops, and three varieties of simple arches.

He directs attention to the fact that one variant from the typical whorl, an S-shaped figure enclosed by a concentric system, may be explained as an effect of the "shoving of the two halves [of the whorl] in opposite directions." "This action is most readily seen, and its effect comprehended, by drawing out upon a card a series of concentric circles of the same width [i.e., equidistant], cutting the figure in two through the center, and then slipping the two parts on each other to any distance desired." There is thus produced such designs as those shown in figs. 106-108.

The descriptive portion of Wilder's account was utilized as the foundation of the revised methods of formulating hypothenar configurations, and for an account of the classification of the variations reference should be made to this latter paper (Cummins *et al.*). It may be well to point out here that the revised methods recognize the existence of strictly duplex configurations, in which there are two distinct open fields in the territory of the hypothenar, a pattern and an open field, or two patterns. Furthermore, an occasional pattern proves to be unclassifiable, and for such patterns there was erected a group formulated as "Y". It may be noted that Wilder's schema does not specifically provide for patterns of the "tented arch" variety (T^u, fig. 16; T^r, figs. 15-17, as well as T^c, a rare form not encountered in the present series), nor does it explain such erratic patterns as figs. 23, 60-63, 109-111, or the combination of a whorl and a loop, figs. 114, 148.

Turning to analysis of the configuration types, it will be useful to catalog the variations, for the purpose of determining both the directions of variation and the frequencies of the types. Such a catalog is presented in the accompanying table. Of first interest is the abundance of patterns, as contrasted with open fields. In the whole series of 2827

TABLE 1

Occurrences of the Varieties of Hypothenar Configurations in 2827 Palms: 1420 Rights and 1407 Lefts. The Symbols Follow Cummins et al. ('29)

VARIETY	RIGHT Number	LEFT Number	BOTH HANDS Number	BOTH HANDS Per cent
A^u	672	697	1369	48.43
A^u/A^c	208	225	433	15.32
A^c	17	12	29	1.03
A^r	14	6	20	.71
T^r	6	1	7	.25
T^u	1	..	1	.04
L^r	247	244	491	17.37
L^rv	16	18	34	1.20
L^rw	2	..	2	.07
L^r/A^c	43	45	88	3.11
L^rv/A^c	2	7	9	.32
A^u/L^r	3	1	4	.14
L^rs/A^c	1	1	2	.07
L^r/L^r	2	1	3	.11
L^rv/L^r	..	1	1	.04
L^r/L^u	10	17	27	.96
L^r/L^uv	2	1	3	.11
L^rv/L^u	..	1	1	.04
L^u/L^rv	1	..	1	.04
L^u	18	28	46	1.63
L^uv	1	..	1	.04
A^u/L^u	47	56	103	3.64
A^u/L^uv	7	4	11	.39
$A^u/L^u/A^c$	1	..	1	.04
$A^u/L^uv/A^c$	1	..	1	.04
L^u/L^u	..	1	1	.04
L^uv/L^u	2	1	3	.11
L^u/A^c	1	1	2	.07
L^uv/A^c	..	5	5	.18
$A^u/L^uv/L^u$	1	..	1	.04
A^r/L^u	2	1	3	.11
T^r/L^u	..	1	1	.04
L^c	23	3	26	.92
L^cw	1	..	1	.04
A^u/L^c	6	..	6	.21
L^c/L^u	..	1	1	.04
$A^u/L^u/L^c$	1	..	1	.04

TABLE 1—*Continued*

VARIETY	RIGHT Number	LEFT Number	BOTH HANDS Number	BOTH HANDS Per cent
W	8	9	17	.60
W/A^c	..	1	1	.04
W/L^u	2	..	2	.07
A^u/w/A^c	1	..	1	.04
A^u/W	6	..	6	.21
S	26	9	35	1.24
Sv	..	1	1	.04
A^u/S	3	1	4	.14
Y	12	5	17	.60
A^u/Y	1	1	2	.07
V	2	..	2	.07

palms there are 976 (34.5 per cent) which bear patterns, the remainder of the hypothenar configurations being patternless.

It is important to note also the relative frequencies of single and duplex configurations. Definitely single configurations (including both patternless and patterned varieties) occur in 2044 palms (72.3 per cent), while the remaining palms have either strictly duplex configurations (such as A^u/A^c, L^u/L^u, L^r/A^c, L^r/L^u and the like) or S and Y forms.

Table 1 is self-explanatory in the matter of incidences of specific types.

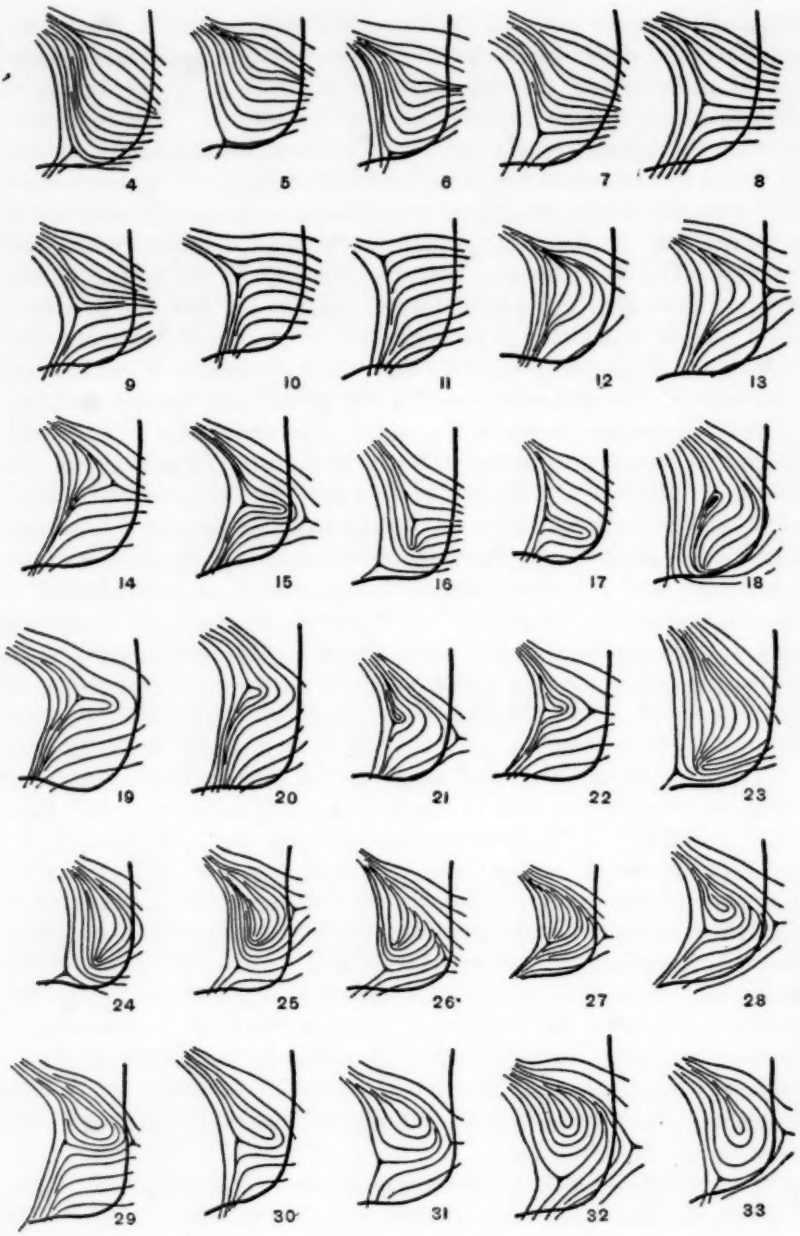
MORPHOLOGICAL DISCUSSION

The association between pads and the patterns which figure their surfaces involves a causal relationship in which both the existence of a pattern, as contrasted with a patternless arrangement of ridges (open field), and the particular variety of the pattern are dependent upon the contour of the pad. For accounts of the discordant interpretations of this association reference may be made to: Bonnevie ('24); Cummins ('26, '29); Hepburn ('95); Kidd ('07); Schlaginhaufen ('05); Whipple ('04); Wilder ('16).

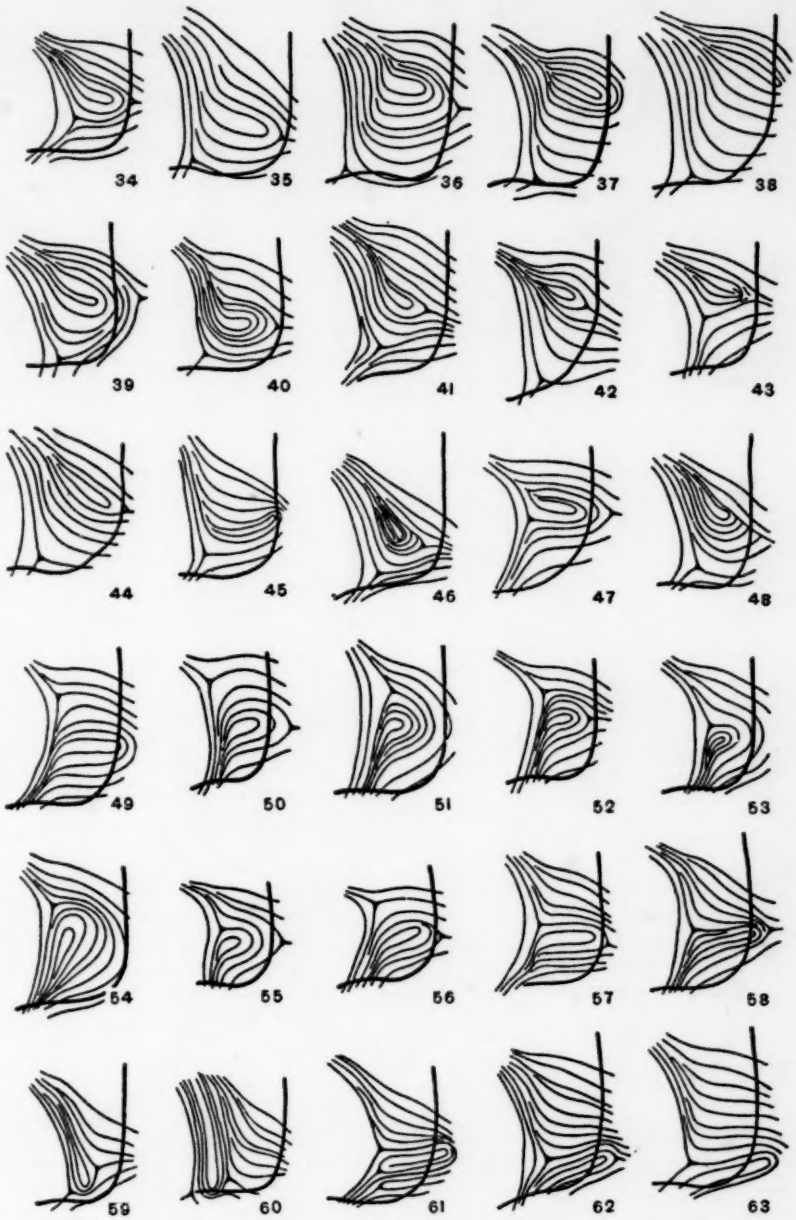
It is desirable, however, to present here a statement of the writer's view of the question, inasmuch as the discussion of the morphology of the hypothenar pattern is based upon it. On examination of the

dermatoglyphics in cases of developmental defects of the hands and feet ('26) the writer concludes that ridge direction, hence the production of patterns and the determination of their particular forms, is wholly dependent upon growth forces in the embryo. The configurations of the bizarre reliefs occurring in these developmental defects are found to conform to the modeling of the reliefs, and no mechanism other than this direct ontogenetic conditioning of ridge alignment seems to account for the consistent association of specific configurations and contours. The character and history of the pads in the normal human embryo (Cummins, '29) afford further support for this interpretation, and it may be added that Bonnevie had arrived independently at a like conclusion. It appears that the ridge-forming capacity is an inherent possession of the epidermis covering the palmar and plantar surfaces, but that the manner in which the ridges align themselves is influenced by growth complexes, perhaps simply mechanical forces, within the embryonic member. Thus, each of the pads elevated above the general surface of the embryonic hand or foot is potentially the site of a pattern, since its very elevation indicates the existence of factors of differential growth, and with the persistence of these factors through the period of ridge-formation the ridges are composed in the form of a pattern, more or less definitely limited from the patternless configurations adjoining the pad. Were it true that all the pads of the morphological series persisted in this fashion each individual would bear as many patterns on each member. An individual so marked is an extreme rarity, owing to the fact that some of the pads ordinarily undergo regression prior to the time in which they would influence ridge alignment. Further, if all the pads assumed the same form, patterns of like configuration would be the expected correlate. The wide variations in dermatoglyphic patterns, both in the number which are expressed and in the varieties of configuration, are in keeping with the actually observed variability in the persistence and reliefs of the embryonic pads. The pads, it is evident, are not endowed with any properties peculiar to them in the domination of ridge direction. Other irregularities of contour are similarly responsible for conditioning particularized ridge alignments. The hypothenar eminence merits attention in this regard, for as has been shown, its configuration conforms to the modeling of the eminence.

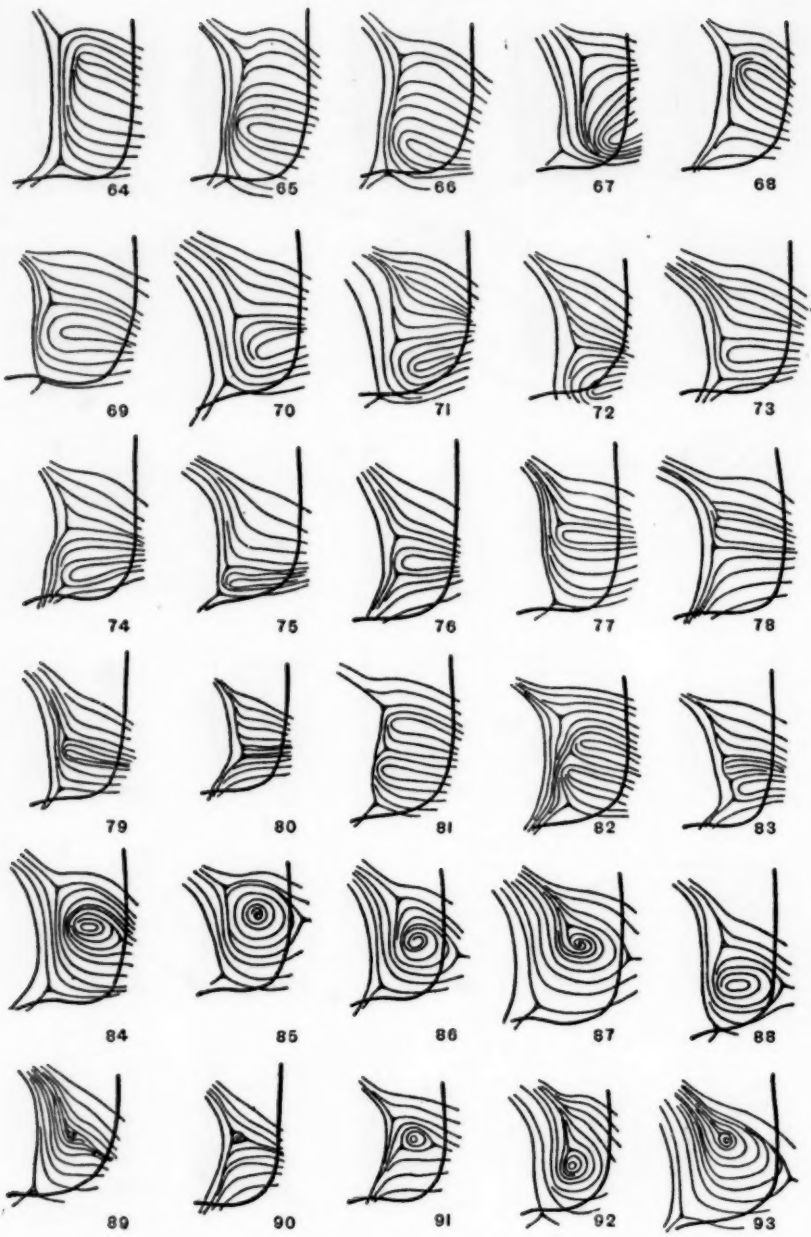
We may then think of the configurations as a secondary manifestation, the individual configurations being independent neither in the general plan of arrangement nor in the detail of pattern forms, and



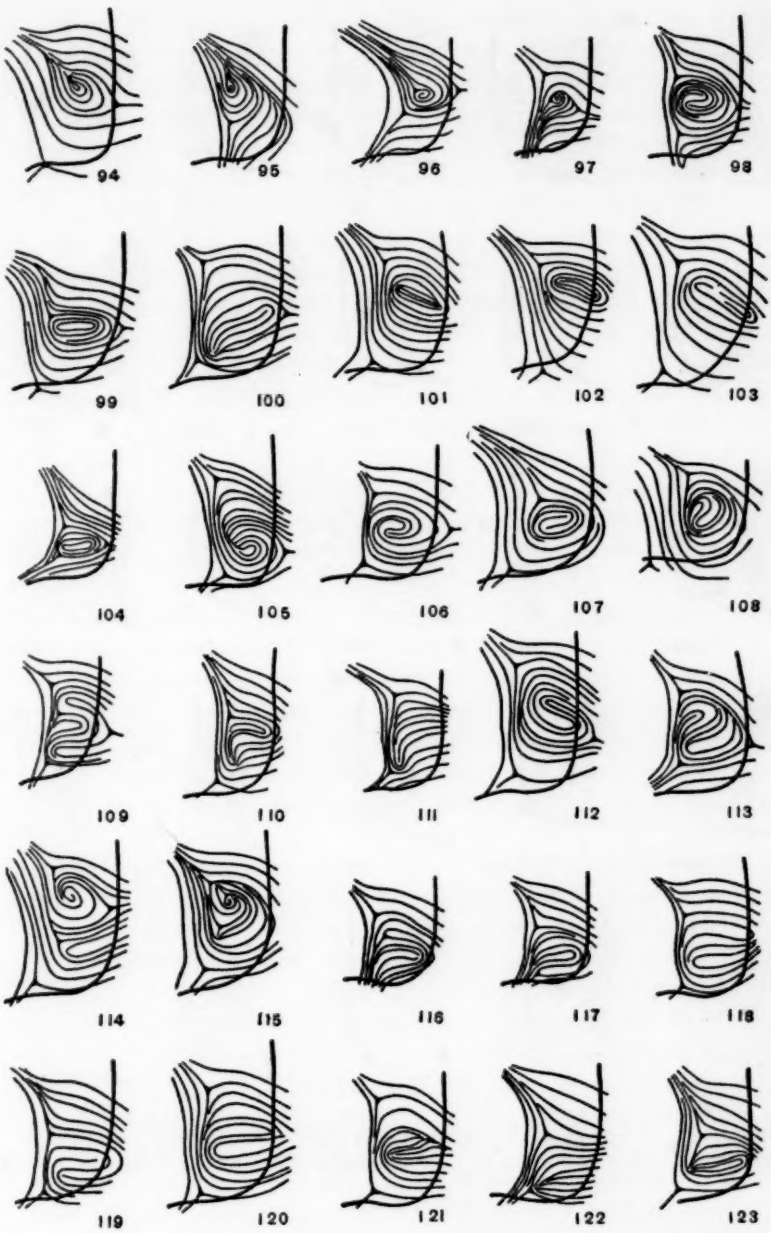
FIGS. 4-148. A SERIES OF TRACINGS OF THE PROXIMAL HYPOTHENAR REGION, REPRESENTING ALL THE TYPES OF CONFIGURATION FOUND IN OVER 2800 PALMS



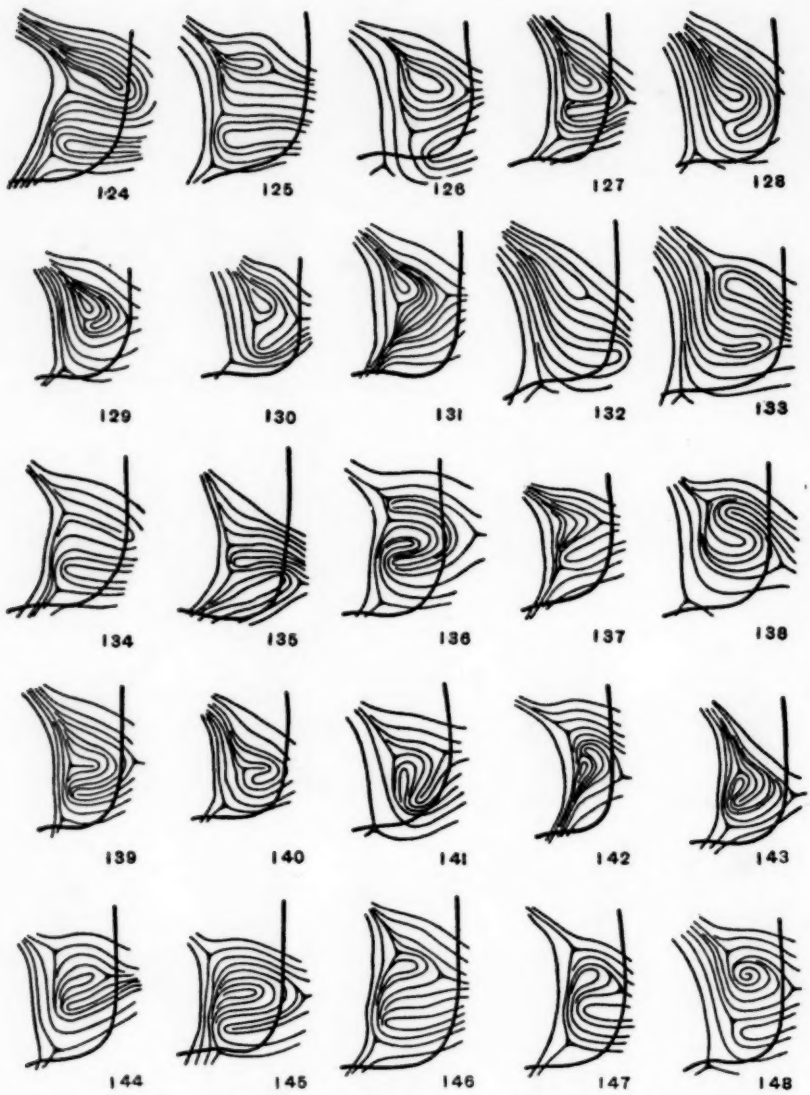
FIGS. 4-148. A SERIES OF TRACINGS OF THE PROXIMAL HYPOTHENAR REGION, REPRESENTING ALL THE TYPES OF CONFIGURATION FOUND IN OVER 2800 PALMS (*Continued*)



FIGS. 4-148. A SERIES OF TRACINGS OF THE PROXIMAL HYPOTHENAR REGION, REPRESENTING ALL THE TYPES OF CONFIGURATION FOUND IN OVER 2800 PALMS (*Continued*)



FIGS. 4-148. A SERIES OF TRACINGS OF THE PROXIMAL HYPOTHENAR REGION, REPRESENTING ALL THE TYPES OF CONFIGURATION FOUND IN OVER 2800 PALMS *(Continued)*



FIGS. 4-148. A SERIES OF TRACINGS OF THE PROXIMAL HYPOTHENAR REGION, REPRESENTING ALL THE TYPES OF CONFIGURATION FOUND IN OVER 2800 PALMS

(*Concluded*)

having no fixity except insofar as the determining factors are constant. The potential expressions of ridge direction, on the contrary, are unlimited. With the acceptance of this position, the qualities of a given pattern, the palmar hypothenar for example, derive significance from the associated hypothenar pad, the vagaries of which are reflected in the surface configuration. The hypothenar pattern, as a true pattern, owes its being to the underlying pad, which in the single case may or may not actually condition a pattern, and if a pattern does appear as a result of its persistence through the period of ridge differentiation, the configuration is to be regarded not as a self-fashioned ridge complex but as a resultant of the pad growth. Each hypothenar pattern is therefore a novel formation, owing nothing of its quality to any pre-existing pattern. If it resembles another example of hypothenar pattern, the immediate associate of the resemblance is to be sought in the similarity of the pad reliefs, which in further analysis resolves itself into similarity of growth of the two pads. A natural outgrowth of the isolation of patterns as self-perpetuating, though mutable, entities is the question of what constitutes the primitive type of configuration, from which other pattern varieties are "converted." From the descriptive standpoint the transition from one to another pattern variety, connecting whorls and arches, may be traced in either direction, sometimes along more than one line, and the issue of the primitive type of pattern need not enter into the present consideration of the hypothenar. (As a matter of fact, dermatoglyphic patterns display evidences of reversibility in evolution, in conflict with Dollo's principle of irreversibility, though this is again a matter which cannot be treated in the present account.)

The familiar patterns of the finger-tips may be first cited in illustration of this point. Finger-print manuals usually provide numerous illustrations of prints, so arranged as to emphasize the relationships of the varying pattern forms. In plates containing many examples (see, for instance, the beautiful plates of Falco, '17-'18) the gradations between loops and whorls, for instance, are nicely seriated, giving ample demonstration that such variations fit into an orderly scheme of natural affinities. Yet among 50,000 finger-prints there are 64 examples classed as "accidentals" (Scotland Yard data, 1905), and patterns so designated represent departures from the typical forms, with configurations which are incompatible with the plan which accommodates the majority of prints. Though the total number of these erratic patterns is relatively small, they cannot be ignored in any fundamental consideration of

pattern morphology. A similar situation might be presented for other patterns, and while varied concrete instances might be cited in reference to the palmar hypothenar it will be perhaps especially pointed to use an example previously recognized by Wilder as a problem pattern not fitting his generalizations. Wilder finds that his sequence of configuration derivatives fits all the cases observed by him except one type, and he had "looked at this anomalous pattern again and again, without coming any nearer to any explanation [of its place in the scheme of pattern modifications]." This hypothenar configuration (fig. 22 in his paper, similar to figs. 114 and 148 in the present account) comprises two patterns—*a whorl and a loop*. The procedure of tracing *origins* through descriptive affinities obviously meets here an overwhelming difficulty, for the whorl member of the configuration retains its typical primitive characteristics, hence the accompanying loop could not have been derived from it in the manner postulated for other patterns.

It is believed that inconsistencies of this nature, whether instanced in the hypothenar or any other pattern, are reconciled in the present interpretation. The formation of a pattern is wholly dependent on factors which condition the configuration *de novo* in each individual, thus depriving it of the generally ascribed persistent individuality and removing the necessity to explain pattern differences on the basis of conversion of ridge arrangements. The integument of the volar surfaces possesses the inherent capacity to form ridges, but the disposition of these ridges is controlled by the *growth of the part*. Considering the range of variation capable of expression in reliefs such as the volar pads, with the attendant dermatoglyphic variations (see figs. 4-148), there appears a new objective in pattern morphology—the correlation of dermatoglyphics with *embryonic* volar reliefs, supplementing the tracing of descriptive affinities and explaining the occurrence of atypical configurations.

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A BIOMETRIC STUDY OF THE RELATION BETWEEN ORAL AND RECTAL TEMPERATURES IN NORMAL AND SCHIZOPHRENIC SUBJECTS*

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I. INTRODUCTION

PHYSIOLOGICAL investigations frequently involve the determination of body temperature and in such investigations the measurement which is taken as an approximation to body temperature is not always the same. Some investigators report the results of oral temperature measurements and others give only measurements of rectal temperatures. Zimmerman (20) has recommended the use of simultaneous oral and rectal temperature measurements for clinical work, but this idea has not been widely adopted.

In studies of the physiology of psychotic individuals the oral sublingual temperature is often an impractical measurement to take because of the uncoöperativeness of the subjects. For this reason the rectal temperature is substituted, and consequently some difficulty is met when it is desired to compare results with published investigations in which the oral temperature was measured. From a clinical standpoint the difference which may exist between the oral and rectal temperatures at any time may be of slight importance, but in certain research problems it is desirable to know the nature of the relation between these variables.

Several writers have reported comparative studies but the statistical analysis is generally confined to statements concerning the difference of the mean oral and rectal temperature. Most of these give figures for the mean difference from 0.4° F.

* With the collaboration of the Research Staff of the Worcester State Hospital.

to 1.0° F.[1] but one writer (Macleod, 14) states the mean difference to be as high as 1.8° F. Of course the differences between single oral and rectal readings have a greater range than the differences between the means. Reference to the literature discloses that numerous observers have found that the difference may vary from 0° F. to 2° F., or even more if taken immediately after exercise or in cold weather. Burton-Fanning and Champion (5) give the limits of variation as 0.0° F. to 0.8° F. Wunderlich (19) states that the rectal temperature is 0.5° F. to 2.0° F. higher than the temperature in the mouth.

It is not always clear if this is the variation to be expected in a single individual from time to time, or whether this is the amount of variation which might be expected to be observed between different individuals. Statements concerning the mean differences disguise the fact that certain subjects might have an individual mean difference quite unlike the mean for the group.

It is desirable, therefore, to extend sufficiently the study of these variables to give data on individual means and variation as well as group means and variation. Furthermore, it is clear that the relationship between oral and rectal temperatures is not completely described by a statement of means, mean differences, and measures of variation. Even if for one individual there is a certain mean difference between oral and rectal temperature, we have no assurance that the oral temperature assumes its highest values at the same time that the rectal temperature is highest.

Benedict and Slack (3) on a study of five men and one woman conclude that a rise or fall in rectal temperature is accompanied by a corresponding rise or fall in temperature in all other internal parts of the body, but the analysis of our data shows this statement cannot be generalized to all individuals, at least in so far as the oral temperature is concerned.

2. SUBJECTS AND TECHNIC

The data analyzed in this study are observations on two groups of subjects. One group consisted of 25 male schizophrenic patients in the Worcester State Hospital. These subjects represented coöperative, chronic cases; the age ranged from 17 to 45 years. In none of the subjects were there any evident signs of physical disease. Observations were made during the months of December 1932, and January 1933. During this time the patients were confined to the wards. The routine

[1] Pembrey (16); Bardswell and Chapman (2); Hewlett (8); Howell (10); Wright (18) and Burton-Opitz (6).

of the patients was such that for the half hour preceding the temperature measurements there was very little activity. In addition to this half hour of inactivity most of the patients sat about waiting their turn for as long as 15 to 45 minutes. All of the patients had had breakfast at least 30 minutes before the morning readings were made. They therefore represented a rather inactive group of subjects living in a relatively uniform temperature environment.

The other group of subjects consisted of 24 normal controls. These were all male physicians, attendants and members of the research staff. The age range was approximately 21 to 45 years. As contrasted with the group of patients, the normal controls were more active, exposed to greater variation in environmental temperature and followed a less uniform routine of activity. In particular, the normal controls did not have the half-hour rest period preceding the temperature measurements. All the controls walked to the experimental rooms, and almost immediately had their temperature taken. In a few cases the morning temperature was taken immediately after breakfast but in most cases it was not taken until one-half to two hours after. About half of the controls lived outside the main hospital buildings and were therefore exposed to cold external air shortly before the morning readings were made. Evidence will be cited in later paragraphs that the error introduced by this variable was but slight.

For each subject simultaneous oral and rectal temperature measurements were made twice a day, between the hours of 8 and 9 A. M. and 4 and 5 P. M. For both the normal controls and the patients the measurements were made on consecutive days, excepting Sundays and other days when certain control subjects were unable to appear for test. This gave 24 pairs of simultaneous oral and rectal readings for each subject.

All measurements were taken while the subject was lying upon a bed fully clothed except for the partial disrobing necessary to permit the insertion of the rectal thermometer. No record was made of the room temperature but at all times it was comfortable. Care was taken to see that drafts did not strike the subject.

Both the oral and rectal thermometers were in place at least 10 minutes as this was considered sufficient time for the thermometer to reach the maximum value. In all cases care was taken that the oral thermometer was correctly placed and that the rectal thermometer was inserted at least 5 cms. In the case of the patients constant watch was

kept in order to be sure that the lips were tightly closed and that there was no manipulation of the thermometer with the tongue. If these requirements were not strictly fulfilled, then the time that the thermometers were in place was extended. In some instances the time was extended to as much as 20 minutes, but generally the coöperation of the patients was such that a reliable measurement could be made in the minimum time.

3. CALIBRATION OF THERMOMETERS

The validity of such observed data depends to a large extent upon the accuracy of the thermometers used. Before any measurements were taken several preliminary tests were made of the thermometers. All were standard rectal clinical instruments manufactured by the Karle Thermometer and Instrument Company. These instruments were calibrated in degrees Fahrenheit and consequently all results reported below are in this unit. Before deciding to use the rectal type thermometer for all measurements, comparisons were made between oral and rectal types. A number of thermometers of each type were immersed simultaneously in water of a uniform temperature. Repetition of this process with water at various temperatures indicated that there was more variation between the types of thermometers than between thermometers of the same type. It was therefore decided to make all measurements with instruments of the same type.

For further tests eighteen rectal thermometers were selected. These were immersed simultaneously in water the temperature of which was determined by a standard scientific thermometer. This test was repeated six times with water at a temperature approximately 96° F., and six times with water at a temperature approximately 100° F. These values were selected since they are near the extremes of non-pathological human temperature measurements. For each of these 12 tests the mean clinical thermometer reading was computed and the discrepancy of each thermometer from this mean tabulated. On the basis of these tabulations six thermometers were rejected. The maximum average discrepancy noted among all 18 thermometers was 0.17° F. and the minimum discrepancy was 0.00° F. After the six most unreliable thermometers were rejected, the average discrepancy of the remaining thermometers was 0.01° F. The maximum average discrepancy for any one of the retained thermometers was 0.07° F. The slight errors in calibration among the retained thermometers were considered to be of

the same order of magnitude as the errors made in reading the instruments. However, they were matched on the basis of their average discrepancy so that we obtained six essentially identical pairs of thermometers.

To each subject used in the investigation was assigned one pair of thermometers and consequently all oral readings on any one subject were taken with a single thermometer and all rectal readings were taken with a matched thermometer.

4. ANALYSIS OF INDIVIDUAL MEANS

The 24 oral temperature measurements for each individual form a frequency distribution of observations for each subject. The corresponding rectal measurements form an analogous distribution. However, it must be noted that these distributions of individual measurements consist of measurements made in the morning as well as measurements made in the afternoon. Since there is marked diurnal variation in body temperature, the treatment of all observations in a single distribution requires some justification. This justification may be found in the comparison of the mean morning temperatures with the mean afternoon temperature. These means are given in Table 1.

TABLE 1

Mean Morning and Afternoon Temperatures for Patients and Controls

	ORAL		RECTAL	
	8 A.M.	4 P.M.	8 A.M.	4 P.M.
Patients	98.17±0.06	98.31±0.06	98.72±0.07	98.86±0.06
Controls	97.80±0.07	98.09±0.06	98.81±0.10	98.91±0.08

Examining the figures for the patients we see that the P. M. readings are slightly higher for both rectal and oral. However, the differences are small in comparison to the standard errors. For example, the mean oral A. M. temperature for the patients is 98.17±0.06 and the corresponding mean P. M. temperature is 98.31±0.06. The difference is 0.14±0.08, which is not significant. The difference in the mean rectal temperature is also not statistically significant.

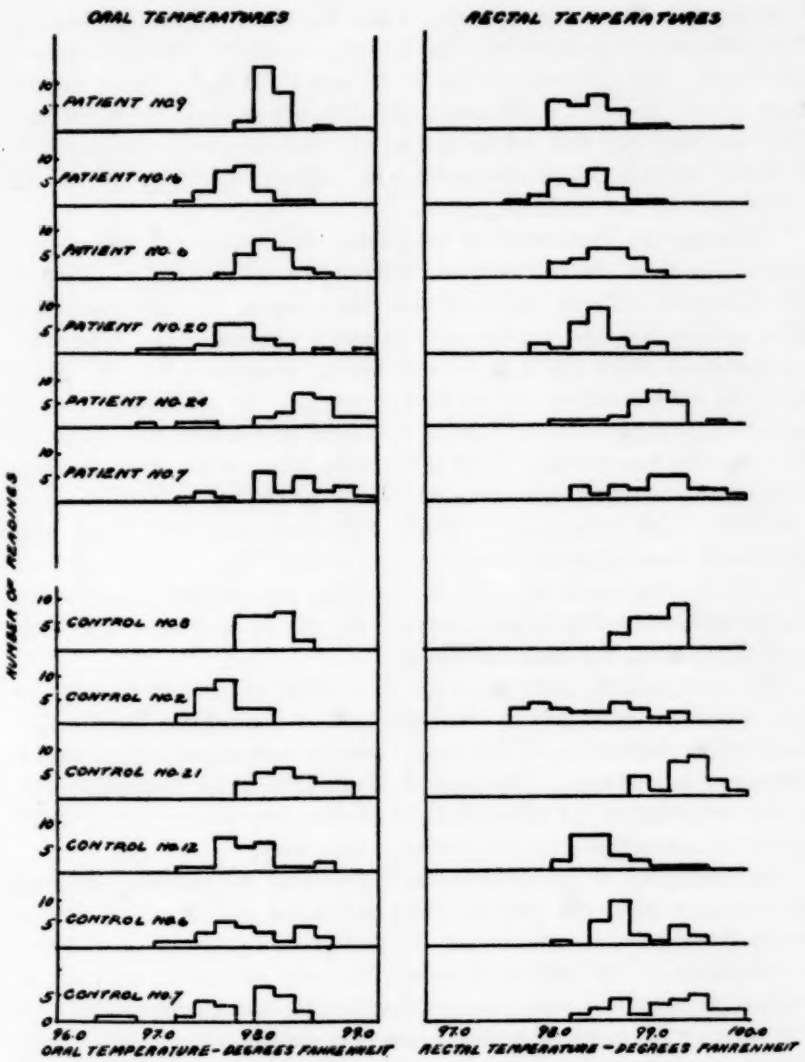

FIG. 1. TYPICAL INDIVIDUAL DISTRIBUTIONS OF ORAL AND RECTAL TEMPERATURES FOR SCHIZOPHRENIC PATIENTS AND NORMAL CONTROLS

The mean oral A. M. temperature for the normal controls is 97.80±0.07 and the corresponding mean for the P. M. is 98.09±0.06. The difference is 0.29±0.09. Statistically speaking, this difference is significant. The difference in the A. M. and P. M. mean rectal temperature is 0.10 ± 0.13; a difference which is not statistically significant. Thus we may say that while one of the differences is significant by statistical criteria, when compared with individual and group diurnal variations they are quite negligible.

This may be illustrated by comparing the differences which were obtained between the morning and afternoon regular ward temperature measurements. These measurements were made in connection with other studies (9) and consist only of rectal temperatures. One reading was made about 4 to 5 A. M. and another about 4 to 5 P. M. Measurements were made on 61 patients every day for 30 days; a second period of 30 days followed two months later and a final 30 day period after another two months. The differences between the mean morning and afternoon readings for the three periods were 1.32±0.04, 1.36±0.03, and 1.32±0.04. These differences are very large compared with those obtained in the present study. This indicates that the 8 A. M. readings and the 4 P. M. readings are similar points on the diurnal temperature cycle and justifies the use of both readings in the same distribution for each individual.

For comparison, histograms of a number of individual distributions are given in Figure 1. Examination of these histograms reveals considerable fluctuation of the mean from subject to subject as well as differences in variation. Obviously it is not valid to fix any value as the correct temperature for all subjects or to state any narrow limits within which the nonpathological temperature may vary.

As descriptive of each individual distribution we compute the mean and standard deviation and use these *individual means* and *individual standard deviations* in examining the nature of the group of subjects. Distributions of the individual means for oral and rectal readings on normal and psychotic subjects are illustrated by histograms in Figure 2. The number of cases, minimum value, maximum value, range, mean and standard deviation for each of the distributions in Figure 2 are given in Table 2.

The mean oral temperature of the control subjects is 97.93±0.06, whereas the corresponding value for the patients is 98.25±0.06; a difference which is statistically significant. For the rectal temperatures

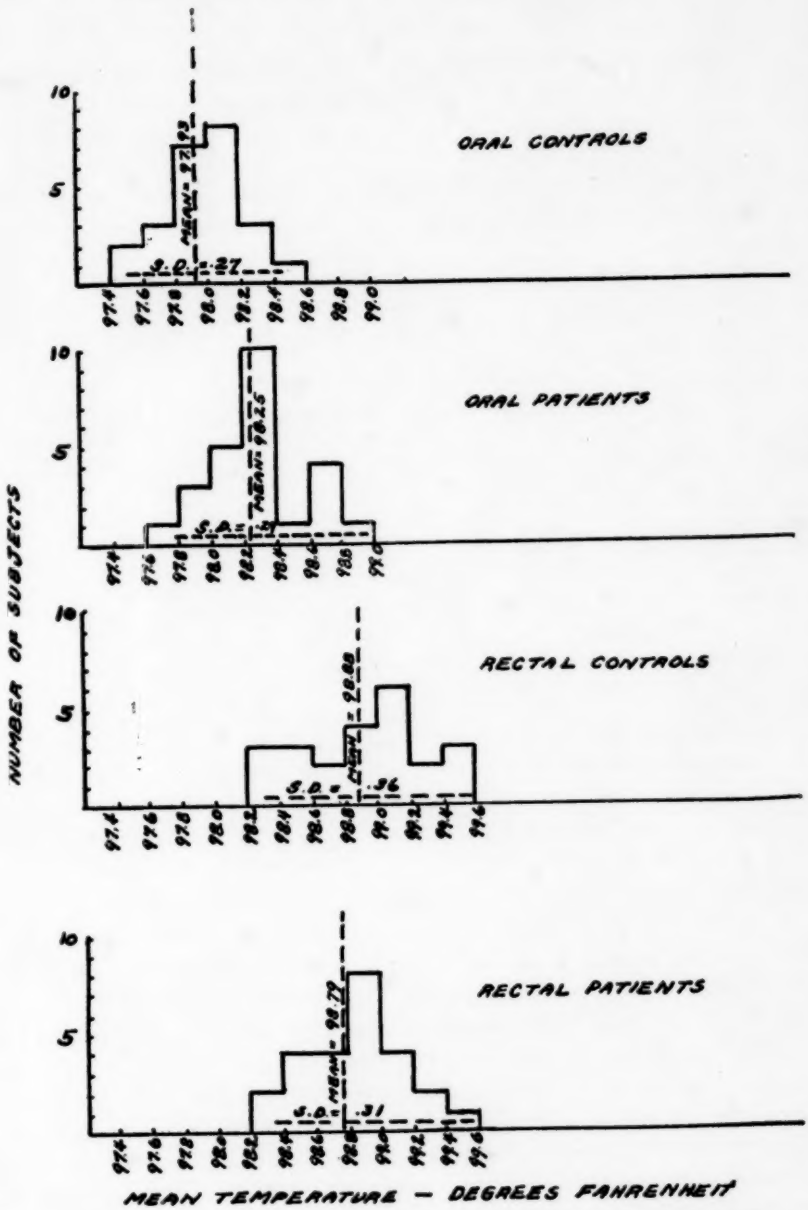

FIG. 2. DISTRIBUTIONS OF INDIVIDUAL ORAL AND RECTAL TEMPERATURE MEANS FOR PATIENTS AND CONTROLS

TABLE 2

Description of the Distributions of Individual Constants of Oral and Rectal Temperatures for Control and Schizophrenic Subjects *

	N.	MIN.	MAX.	RANGE	MEAN	STANDARD DEVIATION
Controls						
Individual Means						
Oral	24	97.4	98.4	1.0	97.93±0.06	0.27±0.04
Rectal	24	98.2	99.5	1.3	98.88±0.07	0.36±0.05
Individual Standard Deviations						
Oral	24	0.19	0.91	0.72	0.39±0.04	0.17±0.03
Rectal	24	0.16	0.73	0.57	0.37±0.03	0.13±0.02
Mean Differences	24	0.42	1.79	1.37	0.95±0.07	0.34±0.05
Correlation Coefficients	24	—.41	.91	1.32	+.56± .07	.34± .05
Patients						
Individual Means						
Oral	25	97.6	98.8	1.2	98.25±0.06	0.29±0.04
Rectal	25	98.2	99.5	1.3	98.79±0.06	0.31±0.04
Individual Standard Deviations						
Oral	25	0.16	0.75	0.59	0.36±0.02	0.12±0.02
Rectal	25	0.24	0.73	0.49	0.36±0.02	0.11±0.02
Mean Differences	25	0.26	0.80	0.54	0.54±0.03	0.13±0.02
Correlation Coefficients	25	.20	.92	.72	+.73± .04	.18± .03

* All errors are standard errors.

we have a mean of 98.88±0.08 for the controls and 98.79±0.06 for the patients. This difference is not significant. Thus we see that the controls have a lower mean oral temperature and essentially the same mean rectal temperature as the patients. In the patients we had a group of subjects with somewhat restricted activity and who were confined in an environment with limited variations in temperature. The normal controls, on the other hand, represented a group of subjects with a normal variety of activities. The fact that some of the control oral temperature measurements were made shortly after the subject arrived at the hospital may account for the fact that the mean oral temperature of the controls is lower than for the patients. This factor, however, is not sufficient to explain completely the difference noted above, for by

reference to Table 1 we may see that the normals had an oral temperature significantly lower than the patients in the afternoon as well as in the morning. The lower P. M. oral temperature of the controls can hardly be explained on the basis of exposure to outside air.

It is important to point out that these data fail to confirm statements by various writers that there is definite hypothermia in schizophrenia.

Kraepelin (11) states "Temperature is usually low, sometimes subnormal with occasional reversal and small range of the daily fluctuations." Singer (17) says that the body temperature is often subnormal. Langfeldt (12) quotes several writers, some of whom found lowered temperatures, others increased temperatures for which there was no apparent reason.

The high incidence of organic disease found in unselected samples of schizophrenic patients may account for the discrepancies between these statements and the results of the present study. The patients studied here are part of a group especially selected to exclude all signs of organic disease.

As mentioned above it is obviously fallacious to define any single value or any narrow limits within which the "normal" temperature must lie. This is supported by the observations of Lyon and Wallace (13) and of Paton (15). It is also impossible to state definite limits below which a measurement would be called subnormal. If it is concluded that our patients show hypothermia then our control subjects must be considered to show it to a slightly greater degree.

It may be noted here that the standard deviation of the distribution of individual means for the control oral readings is 0.27 ± 0.04. The corresponding figure for the patients is essentially the same, being 0.29 ± 0.04. Similarly there is no significant difference in the standard deviation of the distribution of individual rectal means for the controls and patients. For both controls and patients we find the individual rectal means a trifle more variable than the individual oral means. For the controls the standard deviation of the individual rectal means is 0.36 ± 0.05 whereas for the oral means the value is 0.27 ± 0.04. The difference is not significant but is consistent with the corresponding figures of 0.31 ± 0.04 and 0.29 ± 0.04 for the patients.

We can now compare the mean oral and rectal temperatures for the controls. The mean oral temperature is 97.93 ± 0.06 and the mean rectal is 98.88 ± 0.07. Thus for the controls the rectal temperature is on the average 0.95 of a degree higher than the oral. This is the difference

between simultaneous oral and rectal means for the whole group of controls and it does not follow that such a difference will be found for each subject. For the patients we find a mean oral temperature of 98.25±0.06 and a mean rectal temperature of 98.79±0.06. For the patients, then, the difference of the means of simultaneous oral and rectal temperature readings is 0.54 degrees. Analysis of this point may be extended by computing for each individual the difference between his mean oral and mean rectal temperatures. Frequency distributions of these individual mean differences are illustrated in Figure

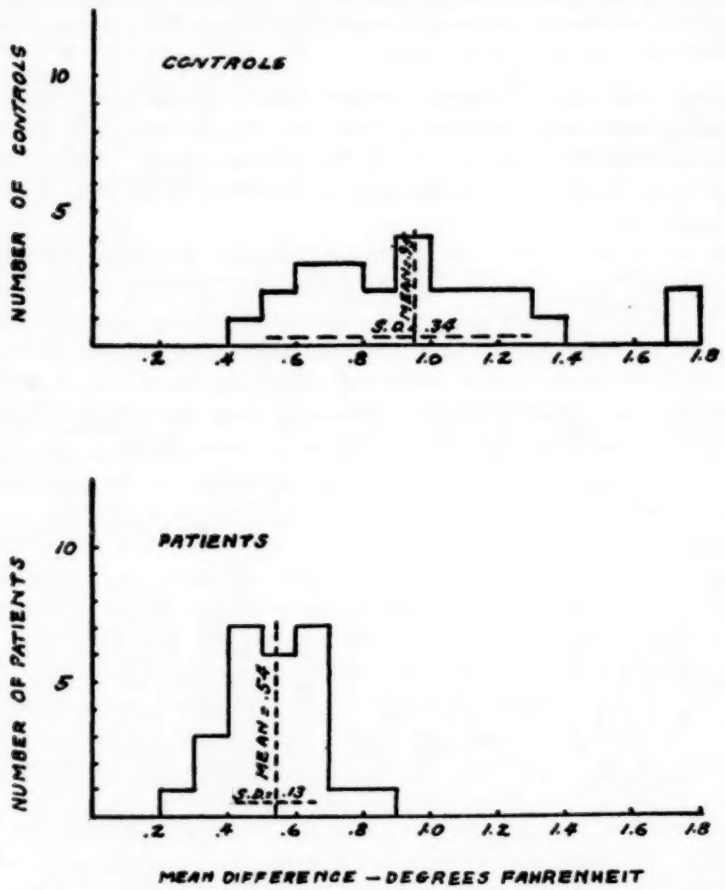

FIG. 3. DISTRIBUTION OF MEAN DIFFERENCES BETWEEN SIMULTANEOUS ORAL AND RECTAL TEMPERATURES FOR PATIENTS AND CONTROLS

3. The constants of these distributions are included in Table 2. We see that one control has a mean difference of 0.42, whereas another has a mean difference of 1.79. Of course, differences between single oral and rectal readings have a wider range than this. The mean for the group is 0.95 ± 0.07 and the standard deviation is 0.34 ± 0.05. The patients constitute a more homogeneous group. The minimum individual mean difference is 0.26 and the maximum 0.80. The mean for the group is 0.54 ± 0.03 and the standard deviation is 0.13 ± 0.02. The patients therefore demonstrate a significantly smaller difference between simultaneous oral and rectal temperatures and are more homogeneous as a group.

5. ANALYSIS OF VARIANCE

An analysis corresponding to the above can be made of the individual standard deviations. The distributions of these individual standard deviations are illustrated in Figure 4, and the constants descriptive of these distributions are included in Table 2. However, the discussion of individual and group variation can be given in a more compact form by the method of the *analysis of variance* (7).

Two types of variation must be considered. There is the variation which is exhibited within an individual over a period of time, and there is the variation occurring between individuals. The analysis of variance examines these two elements of the total variance by considering the fact that if we have data which can be divided into n sets of k observations each, then it is possible to obtain an estimate of the variance of the population in several ways. This variance may be estimated from the total nk observations, from the mean variance in the n sets, or from the variance of the means of the n sets. In our case in which each set of data arises from a single individual, the analysis of variance divides the total variance into variance *within individuals* and variance *between individuals*. The comparisons between these types of variation may be most simply carried on in terms of variance, but since the standard deviation is the square root of the variance, the comparisons can be made in terms of standard deviations. The necessary computations are given in Table 3.

By reference to this table we see that the *within individuals* standard deviation for the oral temperatures of the normal controls is 0.430. This figure may be interpreted as an estimate of the standard deviation of oral temperatures of any normal individual over a period of time pro-

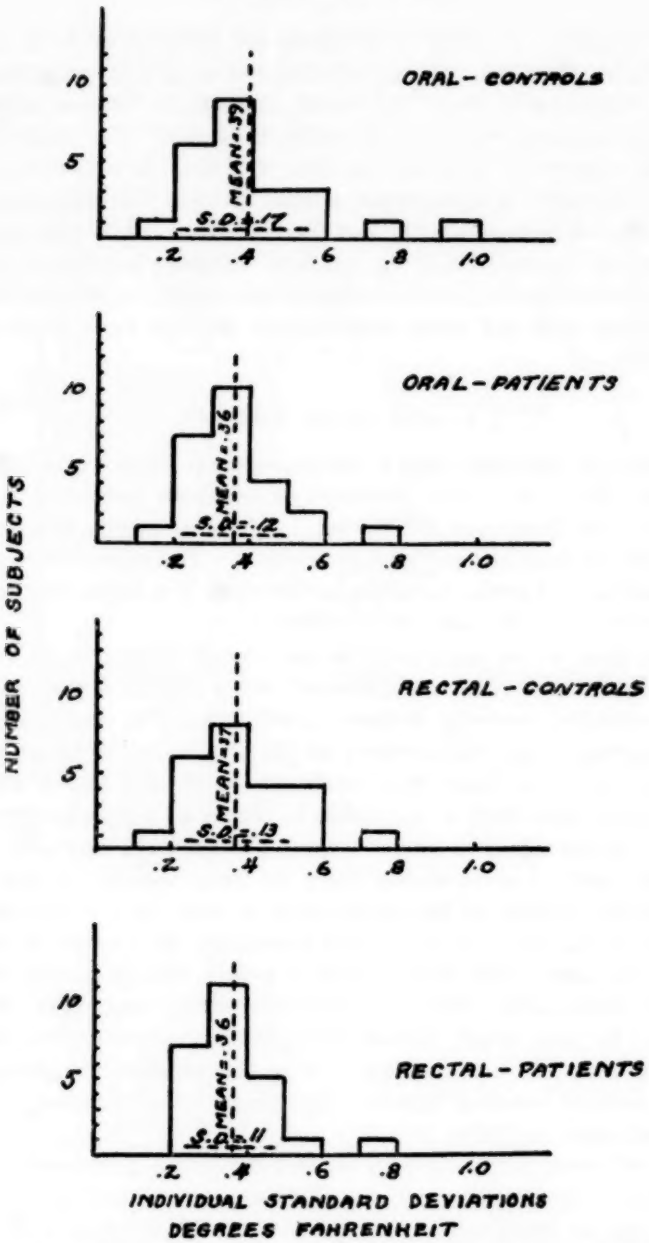

FIG. 4. DISTRIBUTIONS OF INDIVIDUAL STANDARD DEVIATIONS OF ORAL AND RECTAL TEMPERATURES FOR PATIENTS AND CONTROLS

TABLE 3

Analysis of Variance of Oral and Rectal Temperatures for Control and Schizophrenic Subjects

	DEGREES OF FREEDOM	SUM OF SQUARES	VARIANCE	STANDARD DEVIATION
Controls—Oral Temperatures				
Within Individuals	552	102.20	0.1851	0.430
Between Individuals	23	39.95	1.7370	1.318
Totals	575	142.15	0.2472	0.497
Controls—Rectal Temperatures				
Within Individuals	552	89.61	0.1623	0.403
Between Individuals	23	78.91	3.4309	1.852
Totals	575	168.52	0.2931	0.541
Patients—Oral Temperatures				
Within Individuals	575	85.31	0.1484	0.385
Between Individuals	24	49.40	2.0582	1.404
Totals	599	134.70	0.2249	0.474
Patients—Rectal Temperatures				
Within Individuals	575	83.15	0.1446	0.380
Between Individuals	24	54.87	2.2861	1.512
Totals	599	138.01	0.2304	0.480

vided that the conditions under which the measurements are made are similar to those in this experiment. Literally, it is the square root of the mean of the variances of each of the 24 normal subjects. This value of 0.430 may be compared to the *between individuals* standard deviation computed from the same data. The *between individuals* standard deviation is 1.318. If all the oral temperature readings on the controls constitute one homogeneous set of observations, then these two estimates would differ only by an amount which might be ascribed to sampling errors. On the other hand if the difference between these estimates is of a magnitude which cannot be attributed to sampling, we conclude that each set of observations is more homogeneous than the whole group of observations.

The significance of the difference between the two standard deviations may be tested by computing z equal to the difference of the natural logarithms of the standard deviations. The probability that a z of the obtained size would occur by chance is given in Table VI of Fisher's

Statistical Methods for Research Workers (7). By this criterion the observed difference is significant.

For the rectal temperatures of the controls we find a *within individuals* standard deviation of 0.403 and a *between individuals* standard deviation of 1.852. This difference is significant. For the schizophrenic subjects we find similar significant differences between the *within individuals* and *between individuals* standard deviations for both oral and rectal readings.

Further study of Table 3 reveals some consistent differences the significances of which are not established. For both the controls and patients the *within individuals* oral temperature variance is greater than the within individuals rectal variance. But for both the controls and the patients the *between individuals* variance is greater for the rectal temperature. If additional evidence confirms this suggestion, we may say that the rectal temperature is a more consistent measurement for an individual but varies more from individual to individual. This confirms the impression of clinicians that the rectal temperature is the best single measure of the body temperature.

Certain comparisons may also be made between the control and schizophrenic groups. For both oral and rectal temperatures we find that the standard deviation *within individuals* is less for the patients than for the controls. A priori consideration, based on suggestions from other studies, of an unstable physiological organization among schizophrenics, would lead one to expect greater variation within the patients. These results can be considered as partly resulting from the differences in uniformity of the environment and in the amount of activity of the patients and normals, but further analysis will show that this does not explain completely the differences found.

6. CORRELATION OF THE ORAL-RECTAL TEMPERATURE

We have emphasized before the importance of knowing not only the differences between oral and rectal temperature but also the correlation between them. If we are interested in predicting the oral temperature from the rectal temperature or vice versa it is necessary that the two variables be rather highly correlated. We can therefore consider the correlation coefficients between the oral and rectal temperatures for each subject. Scatter diagrams were made and correlation coefficients computed for each of the 49 subjects. Examples of these are given in Figure 5. Such diagrams as these are important in study-

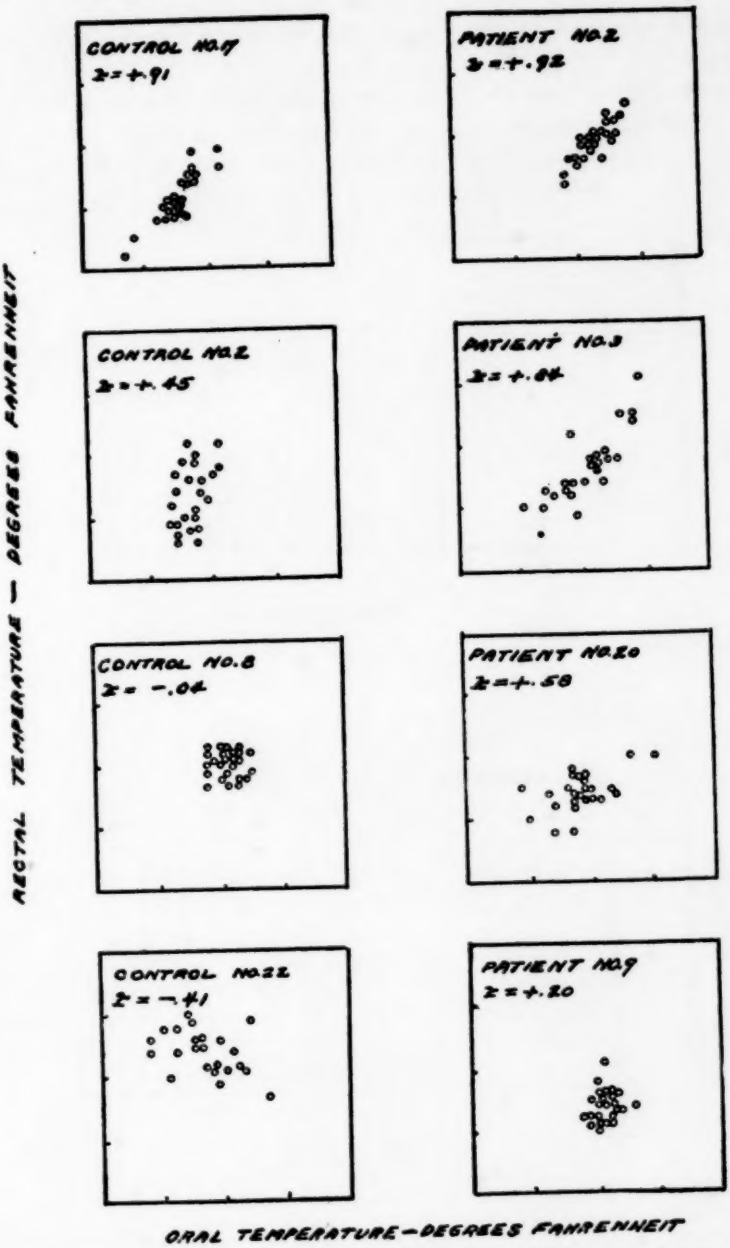

FIG. 5. TYPICAL INDIVIDUAL SCATTER DIAGRAMS BETWEEN SIMULTANEOUS ORAL AND RECTAL TEMPERATURE READINGS FOR PATIENTS AND CONTROLS

ing the variation of the degree of relationship between physiological variables. Such differences in the degree of relationship may prove more important than the differences in the mean value of either variable.

Correlation coefficients based on only 24 observations can of course, be expected to give only an approximation to the true relationship in any individual. Nevertheless these approximations are sufficient to indi-

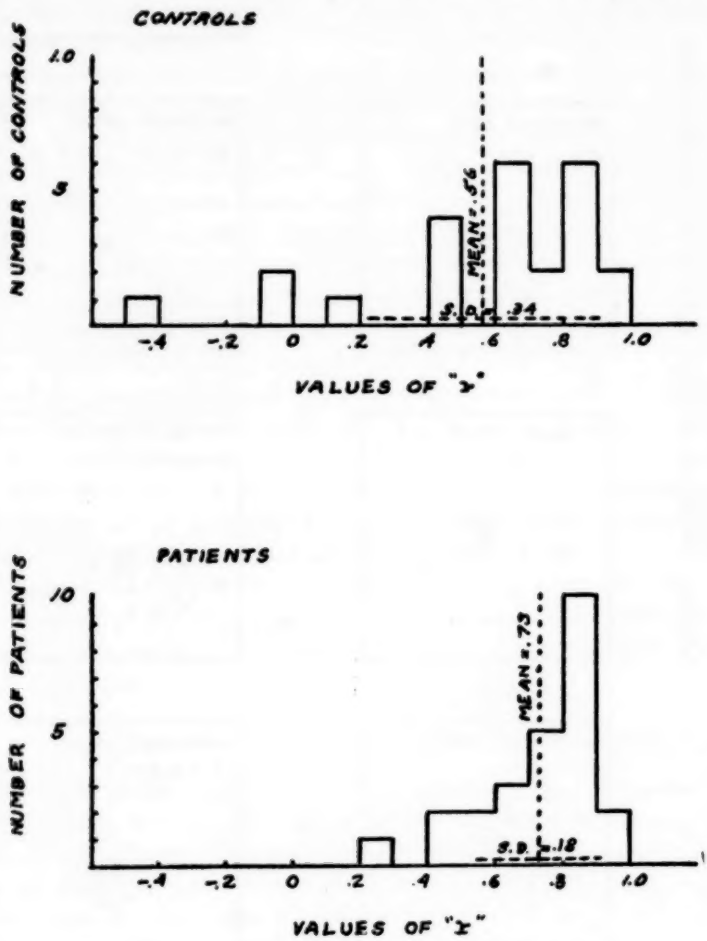

FIG. 6. DISTRIBUTIONS OF INDIVIDUAL CORRELATION COEFFICIENTS BETWEEN SIMULTANEOUS ORAL AND RECTAL TEMPERATURE READINGS FOR PATIENTS AND CONTROLS

cate individual differences in correlation and to make group comparisons. The great amount of individual variation may be seen by examining the examples of scatter diagrams given in Figure 5. In the scatter diagram for Patient No. 2 we find a high relationship between oral and rectal temperatures and it would be possible to predict a value of one for any given value of the other. However, for Patient No. 9 there is almost no relationship. Among the controls we find even a greater range of relationship. Control No. 17 has a high positive correlation but in Control No. 22 the correlation coefficient is —0.41. For this individual the oral temperature tends to be a minimum when the rectal temperature is at its maximum.

Distributions of the correlation coefficients for the control and schizophrenic subjects are given in Figure 6. The constants for these distributions are included in Table 2. The mean correlation coefficient for the controls is $+.56\pm.07$ and the corresponding figure for the patients is $+.73\pm.04$. This difference is significant. There is also a significant difference in the standard deviations of the distributions of correlation coefficients. For the controls the standard deviation is $0.34\pm.05$ and for the patients $0.18\pm.03$. We may say that for schizophrenic subjects, under the experimental conditions of this study, the correlation between simultaneous oral and rectal readings is higher than for the normal controls.

The correlations between individual oral and rectal *means* also show a marked difference. The correlation between the means of the patients is $+.908$, and for the controls the correlation is $+.407$. Scatter diagrams showing these relations are given in Figure 7. The significance of the difference is tested by the computations in Table 4.

The test is made according to Fisher (7, page 175, etc.). The value of z is computed from the formula:

$$z = \tfrac{1}{2} [\log_e (1 + r) - \log_e (1 - r)]$$

The difference between the two values of z is found and this difference tested by comparison with its standard error. This standard error is computed by taking the square root of the sums of the reciprocals of the number of degrees of freedom. The difference is 1.086 ± 0.305 and consequently, we may say that the correlations are significantly different.

The interpretation of this marked difference in relation between the individual oral and rectal means is somewhat difficult. It might be possible to explain the lower individual correlations of the normal

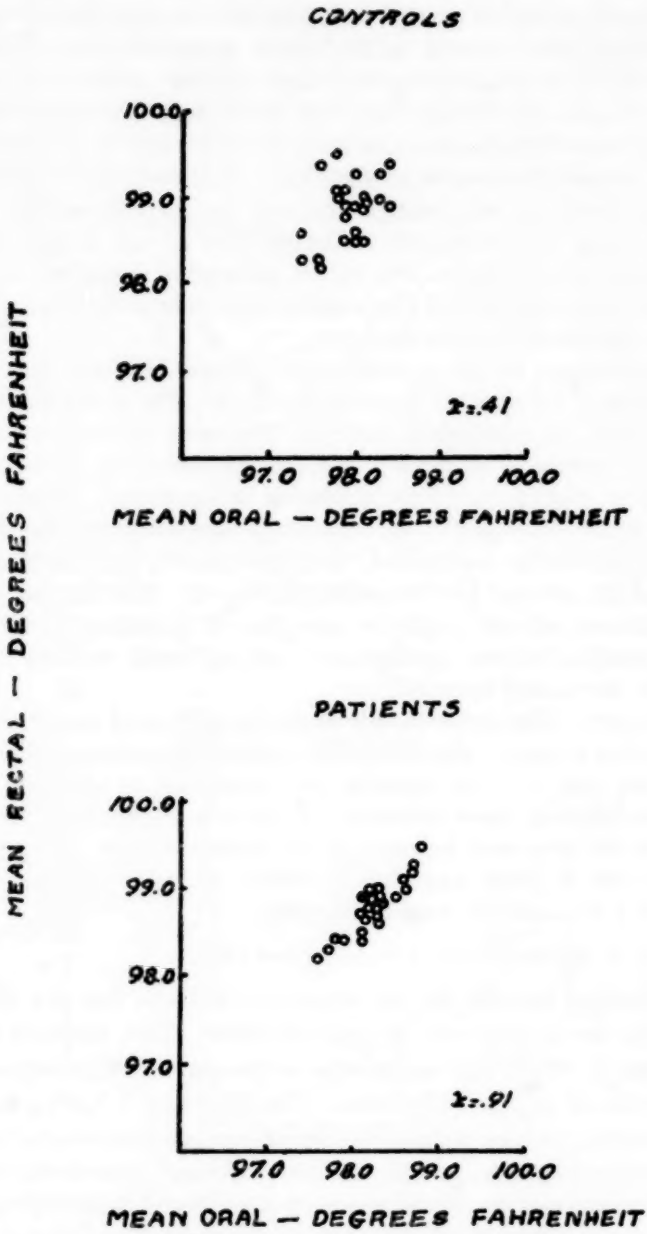

FIG. 7. SCATTER DIAGRAMS SHOWING THE RELATIONSHIP BETWEEN INDIVIDUAL ORAL AND RECTAL TEMPERATURE MEANS FOR PATIENTS AND CONTROLS

TABLE 4

Correlations Between Mean Oral and Mean Rectal Temperatures for Normals and Patients

	CORRELATION COEFFICIENT	z	$n-3$	RECIPROCAL
Normals	.407	0.432	21	0.0476
Patients	.908	1.518	22	0.0455
Difference		1.086 ± .305	Sum	0.0931

controls on the basis of the disturbance introduced by greater variation of external conditions and activity. But it may be questioned if it is legitimate to extend this explanation to the two correlations at hand. It is easy to see that variation in external conditions and activity might reduce the correlation obtained within an individual. Here, however, more is required. To reduce the correlation between individual oral and rectal *means* the activity or environmental changes must be of such a nature as systematically to displace one or the other mean. That is, people must appear with relatively low oral means and high rectal means or with relatively high oral means and low rectal means. But any condition or activity tending systematically to displace the oral or rectal mean temperature in the controls, would be expected to increase the *between individuals* variance. The analysis of variance does not confirm this expectation. Greater variation among the normals in these related conditions should and does increase the *within individuals* variance and does lower the mean individual correlation. But if this explanation is to be extended to account for the lower correlation between the individual oral and rectal means we should have an increase in the *between individuals* variance. Table 3 shows that only on the rectal temperature do the normals show greater *between individuals* variance while the patients have greater variance in the oral temperature.

More definite information can be obtained by an examination of the co-variation regression coefficients (1). For the normal controls the *within individuals* regression coefficient of rectal on oral is 0.468. For the schizophrenic subjects the corresponding coefficient is 0.741. For the *between individuals* coefficients we get the two figures of 0.651 and 0.960, for the controls and patients respectively. These figures indicate

a fundamental difference between the controls and patients. The correlation coefficients indicate a difference in the *degree* of relationship. These regression coefficients go further by indicating a difference in the *manner* of relationship.

Explanations based on supposed differences in environment and activity will not explain these facts, and we may therefore say that the observed results indicate fundamental differences in the physiological organization of our controls and patients. However, though we have shown that there are fundamental differences in the temperature mechanisms of our patients and controls, further study is necessary to indicate the nature of such differences.

8. SUMMARY

In a study of the relationship between oral and rectal temperatures of 25 schizophrenic patients and 24 normal controls, 24 simultaneous oral and rectal temperature measurements were made on each. Morning and afternoon readings were analyzed in combined distributions since the differences were small.

Detailed statistical analysis showed the following results: (a) The normal controls have a slightly lower oral temperature than the patients, but no significant difference is shown between the mean rectal temperatures; (b) the mean difference between oral and rectal temperature is less for the patients than for the normals; (c) the individual normal control is more variable from time to time than is the individual patient. The differences in variation are small and not significant, but are consistent for both oral and rectal temperature; (d) the group variation, obtained by considering the variance of individual means is greater for the normals on rectal temperature, but greater for patients on oral temperature. Since the differences are not significant we say that the group variation of oral and rectal temperature is essentially the same for patients and controls; (e) the mean individual correlation coefficient between simultaneous oral and rectal temperatures is significantly higher for the patients; (f) the correlation coefficient of the individual oral and rectal means is significantly higher for the patients than for the normal controls; (g) the regression coefficients of rectal temperature on oral temperature are different for patients and controls.

Lesser activity and more uniform environmental temperature of the patients undoubtedly has some effect on these results, but detailed analysis has shown that such an explanation is insufficient. While no marked difference is found in mean temperatures of the patients and controls, the important differences found in the *degree* and *manner* of the relation of oral to rectal temperatures indicate that the organization of the temperature regulating mechanisms in schizophrenia is different than in our normal controls.

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HOMICIDE IN NEW YORK STATE

A STATISTICAL STUDY OF THE VICTIMS AND CRIMINALS IN THIRTY-SEVEN COUNTIES IN 1921-1930*

BY J. V. DEPORTE AND ELIZABETH PARKHURST

THE termination of human life is, in the majority of cases, accidental or consequent upon the wearing out of some vital organ. Accidents in the broad meaning of the term may be said to include not only the technical group of external causes, but also morbid conditions resulting from encounters with death-carrying bacilli. Then there are the fatalities caused by malignant tumors, when, for reasons as yet unknown, some cells in the body go wild and eventually destroy life. The residue of deaths is brought about directly by the hand of man in the form of suicide or homicide.

Homicide, the killing of one human being by another, may be justifiable (legal executions), excusable (accidental or in self-defence), or criminal. The killing of human beings in warfare is generally considered as either a justifiable or an excusable form of homicide.

A comparison between the number of victims of criminal homicide and legally sanctioned destruction of life on a much larger scale by means of war is quite striking. According to the best available figures, nine million men were killed in battle or died from wounds and sickness in the course of the World War. The indirect loss of life among the general population from the sequelae of the war (epidemics, civil strife, etc.) was much greater, some estimates being as high as thirty million. If the criminal homicides in Europe and in the United States were to continue at the present rate, it would be a matter of four centuries before the cumulative total would equal the losses sustained by the belligerent armies during the four years of the war, while the maximum estimate of the lives destroyed directly and indirectly by that man-made cataclysm would be reached only in the thirty-seventh century.

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* From the Division of Vital Statistics, New York State Department of Health.

For many years the United States has held the unenviable position of preeminence in the number of criminal homicides.

A veteran investigator of the problem, Dr. Frederick Hoffman, states in his latest annual review of this subject that "human life was never as cheap and insecure in the United States as it is at the present time and murder is decidedly more common in this country than in any other country of the world which makes the claim of being civilized."(1)

In 1931, homicides in the Death Registration Area totalled 11,160. The rate of 9.3 per 100,000 population was more than eighteen times the corresponding figure for England and Wales. Among the forty-seven states of the Area the rate ranged from 1.1 in Vermont to 29.4 in Florida. The six New England states, together with Idaho, Iowa, Minnesota and the two Dakotas, with rates under 3, were at the bottom of the list. With the single exception of Nevada (21.7), the group of ten states with the highest rates were all in the South.

Numerous articles and whole volumes have been written in which the situation is considered from various points of view. In attempts to discover the underlying causes, the old quarrel between heredity and environment is usually brought to the forefront. Some adherents of eugenic fundamentalism point to a logically simple path of action: eliminate the undesirable strains through segregation and sterilization, inaugurate the propagation of men and women possessed of superior physical, mental, and spiritual qualities and within a historically short period the earth will be peopled by only worthy creatures.

As a striking example of the absurdities resulting from a consistent development of this extreme position, we may recall a paper distributed at the 1932 meeting of the American Association for the Advancement of Science, in which The Human Betterment Foundation of Pasadena, California stated that there are in this country "eighteen million persons who are, or at some time during life will be burdened by mental disease or mental defect and, in one way or another, a charge and tax upon the rest of the population. . . . There is one outstanding, practical, humane measure which, properly administered, will go far to change the trend toward human deterioration. This measure is the sterilization . . . . of men and women who are so seriously defective that for the protection of themselves and their families, of society and of posterity, they should not bear and rear children."(2)

Scientists are, however, of the opinion that assumptions of such nature are based upon a "profound fallacy. . . . The epoch-making achievement of genetics during the last quarter of a century is the complete, comprehensive, and general demonstration that heredity does *not* mean that like produces like. . . . The only certain guarantee of the worth (of an individual) for the breeding of a superior race (is) not its own superiority, but the superiority of its progeny."(3)

To be sure, Pearl, whom we are quoting, speaks of the vegetable bean, but, to venture an atrocious pun, his statement is undoubtedly true of the human bean as well.

As to the negative phase of the program, "the difficulties, both social and genetic, which beset sterilization as a remedial eugenic measure are so considerable as to make one doubtful of its accomplishing much."(4)

According to Jennings, even if it were possible to apply to humans the methods employed by the animal breeder, the process of ridding the race of defectives would take a thousand years.

Again, certain investigators advocate the beautifully simple hypothesis of the existence of good races and bad races, the former not unnaturally including that human group of which they consider themselves members. Typical of such reasoning in this country is the well known discourse of Dr. H. H. Laughlin, made before a Congressional Committee(5) some years ago, in which disregard (inadvertent, we hope) of the evident differences in the age composition of the native and foreign-born sections of our population enabled him to "prove" the mental and spiritual inferiority of the immigrants from certain countries of southern and eastern Europe.

The proponents of environment, differing widely in their specific views, are agreed that in the main the causative factors of homicide are to be sought outside the germ plasm. They argue that in no other way could one explain the striking disparity in the homicide rates not only of different countries but of sections of the same country. If, for example, "undesirable" racial elements are responsible for the high homicide rate of New York State, why should the ratio of murders be even higher in certain states, whose white population is almost entirely native-born of Anglo-Saxon origin? Similarly, the genetic argument cannot explain the low homicide rate of Australia, a country even younger than the United States, whose early settlers were, in many cases, deported to the new continent as transgressors against the laws of their day.

Any dispassioned study of crime must have a quantitative basis; but here, as is the case with so many of our other national problems, the necessary objective measurements are practically non-existent. "It is impossible to get much information [about the sex, age, race, and nativity of the criminal population] from courts and police."(6) Only since January 1, 1930 has there been anything resembling a nation-wide collection, by means of monthly reports from over fourteen hundred cities, of statistics of even important crimes "known to the police."(7)

It has, therefore, seemed worth while to assemble and to analyze all of the pertinent facts relating to homicide (exclusive of infanticide and criminal abortions) in the territory under the jurisdiction of the

New York State Department of Health, i.e., the State, exclusive of New York City. The period considered was the decade 1921-1930. The data relating to the victims were obtained from the certificates of death, while those for the convicts were secured through the kind coöperation of the county district attorneys. For various reasons the desired statistical items were available for only thirty-seven of the fifty-seven upstate counties. In the general discussion the experience of the entire State, outside of New York City, will be considered; the parallel comparisons between homicides and convictions will, of necessity, be limited to the thirty-seven counties.

GENERAL OBSERVATIONS

The recorded number of deaths in upstate New York in 1921-1930, which were classed under the technical head of homicide, totalled 1,952. This term, however, includes infanticides (216) and criminal abortions

FIG. 1. HOMICIDES AND CONVICTIONS FOR HOMICIDE, PER 100,000 POPULATION, BY COUNTIES: NEW YORK STATE, 1921-1930

The number above the name of county is the rate of homicides; the number below the name is the rate of convictions. Information regarding convictions for homicide was available for only thirty-seven counties.

(130). The information given in the certificates of death for the last two groups is to a considerable extent fragmentary or of doubtful veracity; besides, the problem presented by these deaths is of a different nature from the other types of homicide. For these reasons we have limited ourselves to a discussion of the 1,606 homicides (males, 1,237; females, 369), which represent what are generally considered murders.

The homicide rates of the fifty-seven counties ranged from a minimum of zero in Lewis (the only county in which no homicides were recorded) to a maximum of 5.3 in Erie. (See Fig. 1). The rate for the entire area was 3.0; three counties had rates of the same magnitude (3.0), forty-two had lower, and twelve had higher rates. Among the larger cities with a population over 50,000 the maximum rate was that of Buffalo, 5.5; followed by Niagara Falls, 5.4. Mount Vernon had the lowest rate, 1.7. Among the smaller cities, Lackawanna had the highest rate, 15.9.

The urban area, which includes all incorporated places over 2,500, had a rate of 3.5, while the rate of rural New York was 2.0. The majority of the deaths in the urban area occurred in hospitals, 602 out of a total of 1,161. The reverse was, of course, the case in the rural area, where out of 383 deaths only 59 occurred in hospitals. The urban and rural rates cannot be depended upon as measures of the homicide situation in the two respective areas, because the urban rates are undoubtedly weighted unfavorably by the deaths in city hospitals of an indeterminate number of rural residents.

The number of homicides in State institutions (prisons, hospitals, etc.) totalled 62, of whom 28 were inmates of hospitals, 24 prisoners, 3 prison-guards, and 7 hospital attendants.

TREND OF THE HOMICIDE RATE

The curve of the homicide rate in upstate New York does not exhibit any definite trend. During the twenty-three year period 1910-1932 the minimum of 2.6 per 100,000 population was recorded in 1920; the maximum, 4.0, in 1921 and again in 1927. It may be remarked, parenthetically, that in New York City the situation was somewhat similar, with the exception of a marked rise of the rate in the last three years. The specific death rates by age in 1921-1930 indicate a slight downward tendency among adult males, particularly between 25 and 45, and a corresponding rise in the younger ages. Among females, the death rates at practically all ages, and, consequently, the total death rate, moved slightly upward.

HOMICIDES ACCORDING TO SEASON

The distribution of homicides according to seasons of the year was as follows:

	Males	*Females*
Total	1,237	369
January-March	263	80
April-June	276	92
July-September	376	102
October-December	318	95
Unknown	4	..

The highest number of homicides was recorded in the summer quarter, July-September; the lowest, in the winter months, January-March. When correction is made for the unequal number of days in the months it is found that the summer excess of homicides over the winter minimum equalled 40 per cent for males and 25 per cent for females.

MEANS OF HOMICIDE

The distribution of homicides according to sex, color, general nativity, and the means employed is given in Table 1.

By far, the most common means of homicide was firearms, 64 per cent of the deaths of males and 59 per cent of the deaths of females being caused by this agency. The proportion of foreign-born males killed by firearms, 70 per cent, was higher than the corresponding proportion for the native-born, 63 per cent. For females, the relation was reversed: 58 per cent for the foreign-born and 64 per cent for the native-born. In the foreign-born population, firearms figured most frequently among the Italians, being responsible for 79 per cent of the 348 homicides in that group. The proportion of cases in which cutting and piercing instruments were used was strikingly high among Negroes —38 per cent as compared with 13 per cent for the native- and foreign-born white; firearms were, however, in first place—47 per cent.

We shall now proceed with a comparative analysis of the statistical facts relating both to the victims and criminals in the thirty-seven counties of the State for which the necessary information could be obtained. These counties have a total area of 29,749 square miles and a population, estimated as of January 1, 1926, of 3,835,091, representing respectively 63 and 73 per cent of the corresponding figures for the entire State, outside of New York City. In this territory are located five of the

TABLE 1

Deaths from Homicide (Exclusive of Infanticide and Criminal Abortions) by Sex, Color, General Nativity, and Means Employed: New York State, Exclusive of New York City, 1921-1930

	TOTAL	WHITE			COLORED	
		Native-born	Foreign-born	Country of birth not stated	Negro	Other
Males						
Total	1,237	483	544	58	146	6
Firearms	787	305	380	26	73	3
Cutting and piercing instruments	194	61	70	11	52	..
Fracture of skull, blow on head, means not stated	78	28	32	6	9	3
Fist or kick—fight	74	40	26	3	5	..
Blunt instruments	60	24	27	4	5	..
Strangulation, asphyxiation	15	12	1	2	..	..
Burns, acid, poison	8	4	3	..	1	..
Drowning	6	5	1	..	..	..
Exposure, abandonment	1	..	..	1	..	..
Other means	14	4	4	5	1	..
Females						
Total	369	213	100	13	40	3
Firearms	218	137	58	7	15	1
Cutting and piercing instruments	71	31	16	5	18	1
Strangulation, asphyxiation	22	13	6	1	1	1
Blunt instruments	15	5	7	..	3	..
Fracture of skull, blow on head, means not stated	11	4	6	..	1	..
Fist or kick—fight	10	6	3	..	1	..
Burns, acid, poison	9	7	1	..	1	..
Drowning	3	2	1	..	..	..
Exposure, abandonment	1	1	..	..	..	..
Other means	9	7	2	..	..	..

seven cities over 100,000 population: Albany, Buffalo, Rochester, Syracuse, and Utica, and a large number of smaller urban places. The distribution of the population, according to general nativity and color, was as follows: native-born white, 3,177,273 (82.8 per cent); foreign-born, 614,984 (16.0 per cent); Negroes, 37,803 (1.0 per cent); the remainder, 5,031, being American Indians and "other colored." The number of males and females was practically the same, males exceeding females by 4,849—or less than three-tenths of 1 per cent; in the group of native-born white there were more females than males, the excess equalling 34,961 (2.2 per cent); in the group of foreign-born, males exceeded females by 37,392 (12.9 per cent) and in the Negro group by 1,459 (8.0 per cent).

HOMICIDES AND CONVICTIONS ACCORDING TO AGE, SEX, COLOR, AND COUNTRY OF BIRTH

The number of victims of homicide totalled 1,166, of whom 890 were males and 276 females; 388 persons, 363 males and 25 females, were convicted for homicide during the ten-year period. Of the male convicts, 46 were executed. Thus, there was one conviction for every three homicides and one execution for every 25 homicides. Although a conviction for homicide does not always occur in the year in which the crime is committed, the overlapping at the beginning of the ten-year period is for all practical purposes offset by a reverse relationship at the end of the period and the ratios just given are not seriously affected by the lack of exact correspondence between the two sets of figures.

The distribution of the homicides and convictions according to sex, color, and country of birth is shown in Tables 2a and 2b.

Of the 1,166 victims, 632 were native born: white, 517; Negroes, 112; Indians, 3. The foreign-born totalled 481, including 3 Negroes and 1 Japanese. The country of birth of 53 persons was unknown or not stated. Of the foreign-born white, 261, or 55 per cent, were Italians.

The outstanding fact in this table is the far greater extent to which the Negroes and the foreign-born whites are victims of homicide than are the native-born whites. Although the Negroes represent but 1 per cent of the population of the thirty-seven counties, 10 per cent of the victims of homicide were of that race; murdered persons of foreign birth represented 41 per cent of the total—more than double the proportion of the foreign-born in the population.

TABLE 2a

Deaths from Homicide (Exclusive of Infanticide and Criminal Abortions) in 37 Counties of New York State, by Sex, Color, and Country of Birth of White Persons, With Average Annual Rates per 100,000 Population of Both Sexes: 1921-1930

COLOR AND COUNTRY OF BIRTH	PERSONS		MALES	FEMALES
	Number	Rate per 100,000 population		
Total	1,166	3.0	890	276
White	1,047	2.8	800	247
Native-born	517	1.6	352	165
Foreign-born	477	7.8	405	72
Austria	19	16.3	12	7
Canada	24	3.1	16	8
Denmark, Norway, Sweden	3	1.3	3	..
England, Scotland, Wales	11	1.6	7	4
Germany	28	3.5	21	7
Hungary	3	4.0	2	1
Ireland	18	3.7	14	4
Italy	261	21.1	240	21
Poland	56	6.4	43	13
Russia	27	9.7	25	2
Other foreign countries	27	4.5	22	5
Country of birth not stated	53	..	43	10
Colored	119	27.8	90	29
Negro	115	30.4	88	27
Other colored	4	8.0	2	2

Relating the homicides to the population, we find that the Scandinavians had the lowest rate, 1.3, followed by the British and the native-born white, 1.6. The Negroes had the maximum rate of 30.4, the next highest rate being that of the Italians, 21.1. The foreign-born as a whole had 7.8 homicides in 100,000 population; exclusive of the Italians, the ratio was considerably less—4.4.

It is desirable to compare the homicide rates of the foreign-born and of the first native-born generation. The necessary population data not being available by counties, we shall consider the situation in the

entire upstate area in 1921-1930. The rate among persons, one or both of whose parents were foreign-born, was 1.8 or only one-fourth of the rate for the foreign-born, 7.5. Detailed comparison could be made only for those countries of origin that were not affected materially by the territorial changes following the war. The figures for the native-born of foreign parentage and the foreign-born, according to country of origin, were as follows: Canadians, 2.0, 2.9; Scandinavians, 0.5, 2.1; British, 1.2, 1.6; Irish, 2.2, 3.4; Italians, 1.6, 20.0. In other words, in all instances the rate was higher for the foreign-born, the disparity being more than 90 per cent among the Italians.

The figures in Table 2a bring out notable differences in the distribution of the victims according to sex. The risk of a woman being killed was relatively greater among the native-born white than among either the foreign-born or the Negroes. Among the former, one in three

TABLE 2b

Convictions for Homicide in 37 Counties of New York State, by Sex and Country of Birth, With Average Annual Rates per 100,000 Population of Both Sexes: 1921-1930

COUNTRY OF BIRTH	PERSONS		MALES	FEMALES
	Number	Rate per 100,000 population		
Total	388	1.0	363	25
Native-born	231	.7	216	15
Foreign-born	142	2.3	134	8
Austria	4	4.4	4	..
Canada	1	.1	1	..
Denmark, Norway, Sweden	..	..	..	..
England, Scotland, Wales	2	.3	2	..
Germany	5	.6	4	1
Hungary	3	4.8	3	..
Ireland	2	.5	2	..
Italy	91	7.1	86	5
Poland	15	1.7	15	..
Russia	6	2.5	6	..
Other foreign countries	13	2.1	11	2
Country of birth not stated	15	..	13	2

of the victims was a woman as compared with one in four among the Negroes and one in seven among the foreign-born. In the Italian group, with the highest homicide rate, only twenty-one women were murdered compared with two hundred and forty men.

Of the 388 persons who were convicted for homicide (Table 2b), 231 were native-born (including an unknown number of Negroes—color, unfortunately, not being shown in the information supplied to us); 142, foreign-born, of whom 91 were natives of Italy; the country of birth of the remaining 15 convicts was unknown or not stated. The criminals were almost all men; among the native-born, one in 15, and among the foreign-born one in 17 was a woman. It is important to bear in mind in this connection that these figures represent convictions and not indictments and that the relation between the numbers for the two sexes very likely reflects the leniency often exercised by juries, not only in this country but the world over, when the person on trial is of the fair sex.

The rates of conviction were 0.7 per 100,000 population for the native-born and 2.3 for foreign-born. Among the latter, the Italians had the highest rate, 7.1. Here it is essential to observe that the rates of convictions as well as homicides for the Negroes and the foreign-born are influenced adversely by the sex and age composition of these two groups of the population. The weight of this factor will be evaluated later.

The curve of homicides according to age is bell-shaped, having a maximum in young adult life, 25-34 years, the rate falling off in the younger and older ages (Table 3a). Somewhat more than half of the persons murdered were between 25 and 45, the median age for the entire group being 35.3 years. The median age of the males, 35.7, was greater than that of the females, 33.8 years. The highest rate among the males was 9.3; among females, 2.5—both in the age group 25-34 years. Considering the rates among the three large subdivisions of the population, we note the extremely high point of 71.7 among Negro males 35-44 years; among the foreign-born males the highest rate, 24.7, was that of the 25-34 years group; among the native-born white, the maximum, 4.3, was recorded in the group 20-24 years. Among females, the Negroes also had the highest rate, 39.3 at 20-24 years; the corresponding rates for the whites being 3.7 at 25-34 years among the foreign-born and 1.7 at 35-44 years among the native-born.

TABLE 3a

Deaths from Homicide (Exclusive of Infanticide and Criminal Abortions) in 37 Counties of New York State, by Age, Sex, Color, and General Nativity, With Average Annual Rates per 100,000 Population: 1921-1930

AGE	DEATHS						RATES PER 100,000 POPULATION			
	Total	White			Colored		Total	White		Negro
		Native-born	Foreign-born	Nativity not stated	Negro	Other colored		Native-born	Foreign-born	
Males—total	890	352	405	43	88	2	4.6	2.2	12.4	44.8
1-14 years	28	24	1	3	..	..	.6	.5	1.1	...
15-19 years	37	29	4	..	4	..	2.3	1.9	5.1	33.4
20-24 years	94	56	26	..	12	..	6.3	4.3	16.9	63.0
25-34 years	268	93	133	11	31	..	9.3	4.1	24.7	63.4
35-44 years	246	64	140	16	26	..	8.3	3.1	15.8	71.7
45-54 years	125	41	62	9	12	1	5.4	2.6	8.8	56.0
55-64 years	55	27	26	1	1	..	3.5	2.4	5.9	11.0
65 years and over	35	18	13	1	2	1	2.7	1.9	3.6	35.8
Unknown or not stated	2	..	..	2	..	..	..	..	...	...
Females—total	276	165	72	10	27	2	1.4	1.0	2.5	14.9
1-14 years	24	21	..	2	1	..	.5	.5	..	2.4
15-19 years	23	20	2	..	1	..	1.4	1.3	2.4	7.1
20-24 years	28	16	4	..	8	..	1.8	1.2	2.5	39.3
25-34 years	72	36	19	3	14	..	2.5	1.5	3.7	33.3
35-44 years	64	37	21	4	2	..	2.2	1.7	3.0	6.9
45-54 years	37	22	11	1	1	2	1.7	1.3	1.9	6.0
55-64 years	18	10	8	..	..	..	1.1	.8	2.0	..
65 years and over	9	2	7	..	..	..	.6	.2	1.9	..
Unknown or not stated	1	1	..	..	..	..	..	..	..	..

The curve of convictions is, in general, similar to that of homicide (Table 3b). The convicted persons as a group were younger than their victims, their median age being 32.6 years; the males were somewhat older than the females, the ages being 32.7 and 32.2 years.

Since the foreign-born and the Negro populations represented in this paper contain a proportionately larger number of adult males than do the native-born, their total rates of homicide and convictions are to a

TABLE 3b

Convictions for Homicide in 37 Counties of New York State, by Age, Sex, and General Nativity, With Average Annual Rates per 100,000 Population: 1921-1930

AGE	CONVICTIONS				RATES PER 100,000 POPULATION		
	Total	Native-born	Foreign-born	Nativity not stated	Total	Native-born	Foreign-born
Males—total	363	216	134	13	1.9	1.4	4.1
15-19 years	26	17	6	3	1.6	1.1	7.6
20-24 years	52	41	9	2	3.5	3.1	5.8
25-34 years	135	88	44	3	4.7	3.9	8.2
35-44 years	79	35	42	2	2.7	1.7	4.8
45-54 years	40	18	22	..	1.7	1.1	3.1
55-64 years	20	13	7	..	1.3	1.1	1.6
65 years and over	5	3	2	..	.4	.3	.5
Unknown or not stated	6	1	2	3	..	..	..
Females—total	25	15	8	2	.1	.1	.3
15-19 years	1	1	..	..	.1	.1	..
20-24 years	5	4	1	..	.3	.3	.6
25-34 years	9	6	2	1	.3	.3	.4
35-44 years	8	4	4	..	.3	.2	.6
45-54 years	..	..	..	..	..	..	..
55-64 years	1	..	1	..	.1	..	.2
65 years and over	..	..	..	..	..	..	..
Unknown or not stated	1	..	..	1	..	..	..

degree higher because of this reason alone. In fact, if the sex and age composition of the foreign-born were the same as that of the native-born white the homicide rate of the former would be 5.6 instead of 7.8, while, exclusive of the Italians, the rate would be still less—3.2 or only double the rate for the native-born white, 1.6. The standardized Negro rate is 23.2 as compared with the crude rate, 30.4.

The total rate of convictions for the foreign-born was 2.3. A correction for differences in sex and age distribution brings it down to 1.8 and when the Italians are excluded the standardized rate becomes 0.8 or practically equal to the rate for the native-born, 0.7.

It is interesting to note the relation of homicides to deaths from all causes according to age. In 1928, in the entire registration area the ratio increased with age to a maximum in young adult life, decreasing to a minimum in the oldest age group. Among males, this proportion was highest between the ages of 25 and 30 years: 3.8 per cent for whites, and 12.3 for colored. Among white females the proportion was highest, 1.1 per cent, between the ages of 20 and 25, among colored females the maximum was 3.4 per cent between 25 and 30.

For upstate New York these facts are available in greater detail. Since the number of homicides among females was relatively small, we shall consider males only. In 1921-1930 the maximum ratios were as follows: native-born at 20-24 years, 1.2 per cent; foreign-born and Negroes at 25-34 years, 3.4 and 5.0 per cent, respectively. Outstanding among the several groups of the foreign-born whites are the Italians; in a total of 10,632 deaths recorded during the ten-year period, 316, or 3.0 per cent, were ascribed to homicide. In the several age groups the ratio was highest, 8.6 per cent, between the ages of 25 and 35 years. The proportions next in size were between the ages of 35 and 45 years, 5.9 per cent, and 15 and 25 years, 5.6 per cent.

CONJUGAL CONDITION

More than half (58.8 per cent) of the victims whose conjugal condition was known, were married, one third were single, the rest widowed or divorced. Among the convicts the largest group was that of single persons, 47.5 per cent, the number of married being somewhat less, 42.5. The remaining 10 per cent were widowed.

Relating the number of persons murdered and convicted to the general population in the several conjugal groups 15 years of age and over, we find that among the victims the rate for single persons, 4.4, was only slightly above that for married, 3.9, while among the convicts the rate for single persons, 2.1, was more than double the rate for the married, 0.9. Disregarding the numerically unimportant group of divorced persons, it is found that among males, the risk of being murdered was greatest for single persons, 6.8, while among females, those who were married carried the greatest risk, 2.1. The proportion of convicts among unmarried men, 3.7, was more than double the corresponding figure among the married, 1.7; for females, the relation between the rates was reversed (0.1, 0.2).

TABLE 4

Deaths from Homicide (Exclusive of Infanticide and Criminal Abortions) and Convictions for Homicide in 37 Counties of New York State, by Sex and Marital Condition, with Average Annual Rates per 100,000 Population: 1921-1930

	NUMBER			RATES PER 100,000 POPULATION		
	Persons	Males	Females	Persons	Males	Females
Deaths from homicide—						
Total	1,166	890	276	4.1	6.3	1.9
Single	380	321	59	4.4	6.8	1.5
Married	661	480	181	3.9	5.6	2.1
Widowed	70	39	31	2.9	5.4	1.9
Divorced	13	10	3	7.6	11.8	3.5
Unknown	42	40	2	..	..	..
Convictions for homicide						
Total	388	363	25	1.4	2.6	.2
Single	180	177	3	2.1	3.7	.1
Married	161	144	17	.9	1.7	.2
Widowed	38	34	4	1.6	4.7	.2
Divorced	..	..	..	..	..	..
Unknown	9	8	1	..	..	..

The ages of the murdered males and females differed considerably only among single persons: the median age of the males in this group was 27.7 years, exceeding by more than ten years the corresponding age of the females, 16.8. In the other conjugal groups the disparity between the ages was considerably smaller.

The necessary population data by conjugal condition and age not being available for counties, specific rates have been computed for the entire Upstate territory for 1921-1930 (Table 5).

OCCUPATION

Table 6 lists the occupations of the murdered and convicted persons according to sex and general nativity.

Most of the murdered persons of "no occupation" were children of school age; a few were crippled or feeble-minded; the rest were either retired or were said to be out of employment.

TABLE 5

Death Rates per 100,000 Population from Homicide (Exclusive of Infanticides and Criminal Abortions) by Sex and Marital Condition, According to Age, Color, and General Nativity: New York State, Exclusive of New York City, 1921-1930

	MALES			FEMALES		
	Single	Married	Widowed	Single	Married	Widowed
Total over 15 years	6.6	5.5	5.1	1.0	2.1	1.6
15-24 years	4.1	6.4	..	.9	3.3	..
25-34 years	10.7	7.4	16.4	1.4	2.4	6.5
35-44 years	11.0	7.0	11.2	.4	2.4	5.4
45-54 years	7.6	4.6	6.2	.8	1.6	2.9
55-64 years	6.3	3.0	4.8	1.9	.8	1.2
65 years and over	7.0	2.1	3.1	.5	1.1	.4
Native-born over 15 yrs.	3.5	2.7	3.2	.9	1.4	1.3
15-24 years	2.7	5.3	..	.8	2.6	..
25-34 years	5.6	2.9	7.2	1.4	1.4	3.5
35-44 years	3.7	3.0	3.2	.2	1.5	4.8
45-54 years	4.0	2.3	2.7	.9	1.2	3.3
55-64 years	4.0	1.8	4.9	1.8	.5	.7
65 years and over	4.9	1.7	2.3	.6	.2	.1
Foreign-born over 15 yrs.	17.0	11.0	8.5	.7	3.0	2.0
15-24 years	12.4	15.2	..	*	3.9	*
25-34 years	20.0	18.1	41.6		3.1	
35-44 years	25.9	13.6	25.5		3.8	
45-54 years	13.3	8.4	11.0		2.2	
55-64 years	9.8	5.3	6.4		1.8	
65 years and over	8.9	3.1	4.2		3.6	
Negro over 15 yrs.	60.9	46.7	30.9	5.9	21.0	5.3
15-24 years	55.4	8.2	*	*	26.4	*
25-34 years	71.9	61.8			30.9	
35-44 years	46.1	61.3			14.9	
45-54 years	85.7	28.8			9.8	
55-64 years	34.2	26.5			..	
65 years and over	64.5	17.3			..	

* Number of deaths too small to make rates significant.

TABLE 6

Deaths from Homicide (Exclusive of Infanticide and Criminal Abortions) and Convictions for Homicide in 37 Counties of New York State, by Occupation, According to Sex, Color, and General Nativity: 1921-1930

	HOMICIDES				CONVICTIONS		
	Total	Native-born white	Foreign-born white	Negro	Total	Native-born	Foreign-born
Males—total	890	352	405	88	363	216	134
Laborers	265	57	148	53	124	62	60
Skilled workmen	126	49	68	5	69	46	22
Retail dealers	80	16	61	1	10	4	6
Farmers and farm laborers	52	32	17	3	25	15	7
Chauffeurs, teamsters, deliverymen	45	31	11	2	18	13	4
Other proprietors, managers, officials	37	17	18	2	5	3	2
Factory operatives	32	13	14	3	34	17	16
Policemen, sheriffs, constables	24	19	4	..	1	1	..
Salesmen	18	12	6	..	5	5	..
Clerical workers	16	14	2	..	10	9	1
Guards, watchmen, caretakers	13	7	4	..	..	..	..
Railroad employees, not otherwise specified	13	9	3	1	6	5	1
Servants, waiters	13	3	2	7	22	15	7
Professional men	11	9	2	..	8	7	1
Barbers, hairdressers	7	1	5	1	6	3	3
Foremen	7	2	5	..	..	..	..
Others	32	14	14	2	5	4	1
No occupation	69	45	11	2	8	5	1
Occupation not stated	30	2	10	6	7	2	2
Females—total	276	165	72	27	25	15	8
Housewives	178	94	61	18	12	7	4
Servants, waitresses	29	16	4	6	4	3	1
Clerical workers	7	7	..	..	2	1	..
Factory operatives	6	4	1	..	..	..	..
Professional women	5	4	1	..	..	..	..
Saleswomen	3	3	..	..	..	..	..
Forewomen	2	2	..	..	..	..	..
Retail dealers	2	..	2	..	..	1	..
Other proprietors, managers, officials	2	2	..	..	1	..	..
Elevator operator	1	1	..	..	..	..	..
Hairdresser	1	1	..	..	..	..	..
Dressmakers	..	..	..	..	1	..	1
Midwives	..	..	..	..	2	..	2
No occupation	35	29	2	2	3	3	..
Occupation not stated	5	2	1	1	..	..	..

Generally speaking, we have in the table of occupations wage earners, salaried persons, proprietors, farmers, professional people, and officers of the law. A grouping into this smaller number of classes shows that 57 per cent of the victims and 77 per cent of the convicts were laborers—skilled or unskilled. The line of demarcation between these and the other groups does not, however, represent a significant difference in economic levels since practically all of the "proprietors" were merchants on a small scale: butchers, bakers, grocers, fruit vendors, and a few saloon keepers (the statements of occupation, by the way, antedate April 7, 1933). Similarly, the other groups undoubtedly include only a small proportion of persons of legitimately acquired wealth. In general, we may, therefore, say that few of the persons murdered or convicted for murder belonged to the respectable well-to-do classes.

EDUCATION AND RELIGIOUS TRAINING OF THE CONVICTED PERSONS

The degree of education claimed by the men and women who were convicted for murder is indicated in Table 7.

TABLE 7

Education of Persons Convicted of Homicide

	PERSONS	MALE	FEMALE
Total	388	363	25
No education	62	59	3
Elementary school, partial	76	70	6
Elementary school, complete	191	178	13
High school, partial	20	20	..
High school, complete	12	12	..
College, partial	1	1	..
College, complete	5	5	..
Unknown or not stated	21	18	3

Of the men, 16 per cent, and of the women, 12 per cent were said to have had no formal education of any degree. Elementary education, in part or complete, was indicated for 68 per cent of the men convicts and for 76 per cent of the women. None of the latter was educated

beyond the elementary school while among the men, 32 had attended high school and 6 had a partial or complete college education.

Most of the convicts had religious instruction, the distribution being given in Table 8.

TABLE 8

Religious Instruction of Persons Convicted of Homicide

	TOTAL	MALE	FEMALE
Total	388	363	25
Catholics	177	165	12
Protestants	142	133	9
Jews	5	5	..
Other	5	5	..
Unknown or not stated	59	55	4

PREVIOUS CONVICTIONS AND SENTENCES

Of the male criminals, 196 or 54.0 per cent had no record of a previous conviction, one previous conviction was shown in 85 cases, two in 29, three in 15, and four in 16 cases. All of the females belonged to the first category. The distribution according to nativity is given in Table 9.

TABLE 9

Previous Convictions of Persons Convicted of Homicide by Sex and Nativity

	MALE			FEMALE		
	Native-born	Foreign-born	Nativity not stated	Native-born	Foreign-born	Nativity not stated
Total	216	134	13	15	9	1
Previous convictions:						
None	106	84	6	15	9	1
One	56	26	3	..	..	..
Two	19	9	1	..	..	..
Three	12	3	..	..	..	..
Four	12	4	..	..	..	..
Unknown	11	8	3	..	..	..

The past criminal history ranged from violations of the prohibition law to homicide. The number of first offenders was relatively higher among the foreign-born males than among the native-born, the percentages being 63 and 49 respectively. Since on the face of the official records natives of Italy had the highest proportion of convictions for homicide, it is interesting to call attention to the fact that 63, or 69 per cent of the 91 Italians had not been previously convicted for any crime.

The laws of the State of New York recognize four degrees of guilt for homicide: murder in the first degree being a capital offense, murder in the second degree and manslaughter in the first or second degree being punishable by imprisonment.

The degree of guilt of the 388 convicted persons is indicated in Table 10.

TABLE 10

Degree of Guilt of Persons Convicted of Homicide by Sex and Nativity

	MALE			FEMALE		
	Native-born	Foreign-born	Nativity not stated	Native-born	Foreign-born	Nativity not stated
Total	216	134	13	15	9	1
Murder, 1st degree	50	27	1	1	1	..
Murder, 2d degree	84	47	4	3	1	1
Manslaughter, 1st degree	68	53	8	9	7	..
Manslaughter, 2d degree	12	6	..	1	..	..
Manslaughter, not stated	2	..	..	1	..	..
Assault, 2d degree	..	1	..	..	..	..

Of the 80 convicts who were found guilty of murder in the first degree, the sentence of 16 was commuted to life imprisonment, 2 committed suicide, 11 were adjudged insane, 1 was granted a new trial and then found guilty of murder in the second degree, 46 convicts were executed. In the remaining 4 cases the information furnished us apparently referred to the indictment and not the conviction since these criminals were given prison sentences instead of the mandatory sentence of death.

DISCUSSION

The figures presented in this paper indicate that in a large section of the State of New York the Negroes and the foreign-born, especially the Italians, are victims of homicide to a much greater extent than are the native-born white; that the proportion of criminals, as measured by convictions for homicide, is highest among the Italians, while for all the other foreign-born considered as a group (with the necessary corrections made for differences in age and sex composition), it is of practically the same magnitude as for the native-born (including the Negroes).

Before attempting to interpret these findings, it is well to examine the quality of the basic data. The facts about the victims of homicide are, in general, reasonably accurate—perhaps more so than in deaths from natural causes, since the circumstances of every homicide are investigated and not infrequently the information is supplemented or modified by a coroner's inquest. The data relating to the convicts, especially the personal facts, contain, however, a definite, though indeterminate, degree of error. Not all of the statements made by prisoners can be accepted at their face value; for example, Sutherland (8) tells about twenty repeaters, of whom only two gave the same answers at each arrest. Criminals, especially women, frequently claim a degree of education far superior to that which they actually possess. This is also true in regard to statements of occupation.

Finally, one must realize that the rate of convictions is not a good measure of the criminality of a national group because not all indictments lead to convictions. Experience has demonstrated that in ordinary circumstances juries are likely to show leniency to native-born persons, but apply the letter of the law when the defendants are of foreign birth. It seems reasonable to assume that to a certain extent the rate of convictions of the native-born is lower because the number of native-born criminals who escape punishment is relatively greater.

To summarize: the homicide rates presented in this paper may be taken as valid for all practical considerations; the rates of convictions are undoubtedly less accurate, but there is no means by which to measure or even to estimate the degree of their deviation from the truth. The rates for the Italians are, however, so outstandingly high, that it seemed to us desirable and even necessary, in advance of publication, to submit them for criticism and comment to a number of competent sociologists and jurists.

Typical of most of the replies are the following remarks of Mr. Edward Corsi, Commissioner of Immigration in the New York District:

> It is surprising to me that the figures at your disposal should reveal that homicides and convictions are higher among the foreign-born [Italians] than among the native-born. I was always under the impression that the exact reverse was true. The great majority of the cases of homicide that I can think of in the course of my experience as a social worker among Italians, involve native-born men.

A judge, whose name we are not privileged to mention, wrote that if our figures are correct (and this he questioned), they cannot be indicative of conditions throughout the country. He called attention to the fact that the homicide rate for Italy has been steadily declining from the peak of 9.5 in 1913 to 2.7 in 1929 and that at no time was Italy's rate as high as that given in this paper for the Italian immigrants. He believed that in this State prohibition was an important contributing factor in homicide as it was in other forms of lawlessness and crime.

Let us consider separately the three points made in this statement:

(1) Our figures are not indicative of conditions in other parts of the country.

Statistical information about crime in the country at large being most fragmentary, we had to content ourselves with the limited data that could be compiled from published records. For the city of Chicago, we have homicide rates for each of the three years 1923-1925 given in Table 11.

For Philadelphia, we have the rates for 1921-1923 given in Table 12.

Through the kindness of Dr. John T. Walsh, Acting Registrar of Records of the New York City Department of Health, we were able to secure figures for that city for the year 1931. There were in the course of the year 542 homicides: 467 males and 75 females. The white males totalled 356, of whom 47 were native-born of native parentage; 131, of foreign or mixed parentage; and 157 were foreign-born. Negroes numbered 107. The number of white females killed in the course of the year totalled 51: 8 were native-born of native parentage, 15 of foreign or mixed parentage, and 26 were foreign-born. Negro females numbered 23. Since the number of homicides of females was relatively small, we give the rates for males only in Table 13.

TABLE 11

Homicide Rates in Chicago

	1923	1924	1925
Total	13.3	16.7	18.0
Native-born (white and Negroes)	11.4	13.9	15.6
Foreign-born white	18.0	24.1	24.4
Italians	65.4	60.9	98.3

TABLE 12

Homicide Rates in Philadelphia

	1921	1922	1923
Total	6.2	7.4	9.6
Native-born white	3.0	3.4	4.3
Foreign-born white	10.7	11.0	11.6
Italians	24.9	33.9	18.4
Colored	22.2	31.3	47.8

TABLE 13

Homicide Rates in New York City in 1931

AGE	NATIVE-BORN WHITE		FOREIGN-BORN	NEGRO
	Native parentage	Foreign or mixed parentage		
All ages	6.1	9.3	13.1	64.0
Under 15 years	1.5	1.9	...	...
15-19 years	4.5	8.2	6.8	40.9
20-24 years	9.3	16.6	18.8	130.2
25-34 years	13.4	20.4	18.3	96.3
35-44 years	7.7	9.3	13.6	71.9
45-64 years	6.5	14.5	10.3	50.4
65 years and over	...	...	8.5	54.3

Of the 183 foreign-born victims, 81 were natives of Italy; the rate, 18.4, was more than double the next in order—that for natives of Ireland, 7.7, which was based on 17 homicides.

The homicide rate of the native-born, one or both of whose parents were Italians, 7.9, was less than one-half that for the Italian group and only slightly higher than the corresponding rate for persons of Irish parentage, 6.9.

Thus, the situation in Upstate New York is not exceptional, since in Chicago (in 1923-1925), in Philadelphia (1921-1923), and in New York City (1931) the natives of Italy also had a higher homicide rate than any other group of the white population.

(2) The homicide rate in Italy is lower than the rate for the Italian immigrants in this State.

This observation is entirely true. Some minor comparisons are particularly interesting: in the ten-year period 1921-1930 the average annual homicide rate of Turin was 2.0, while that of Buffalo, a city with a population of approximately the same size, was almost three times as high, 5.5. In the same decade, the rate of Messina, the largest city in Sicily, was 3.1—identical with the rate of the city of Syracuse.

(3) If our figures are not fallacious, prohibition is the main causative factor.

An examination of the homicide record of Upstate New York for 1916, the last pre-prohibition and pre-war year, failed to substantiate this point. Of the 80 persons of foreign birth who were killed in that year, 50 were natives of Italy, the rate of 34.2 being more than seven times that for the rest of the foreign-born.

Thus, we are obliged to conclude that the high rates for the Italian immigrants are, in general, descriptive of the existing situation. One is then led to inquire into the causes responsible for this condition.

It has been shown earlier that in Upstate New York the homicide rate among the native-born of Italian parentage was only 8 per cent of the rate among Italian immigrants. The germ-plasm, therefore, has nothing to do with the case. Most of the Italians who were convicted for homicide had not been previously convicted for any crime; in other words, in the eyes of the law homicide was their first anti-social act. It is reasonable to look for an explanation of the high Italian rate in the mores of their homeland, where, as even in our own South, murder in certain circumstances is looked upon as an act of duty. Once the debt of blood is collected, the avenger, if he evades arrest or, as is frequently the case, has his freedom restored by a jury of his peers, resumes the

life of a peaceful and law-abiding citizen. "The Italians are rarely professional criminals. They usually commit felonies only under emotional stress."(9)

A considerable measure of responsibility for the delinquencies of the Italians and other newcomers must be borne by those elements of our native population who take upon themselves the rôle of mentors and guides.

A scene in a story by Arthur Train (10), who for ten years was District Attorney of New York County, illustrates the point: An Italian is charged with the murder of a Daniel Shea, prohibition agent. "Did you know Daniel Shea, the deceased?" . . . "I pay Dan two hundred dollar a month for last tree years," returned Angelo unperturbed, "for keepa da cops away from my place." "Don't you know it's against the law to sell liquor?" "I pay two hundred a month!"

One must also recognize, as Rebecca West (11) pointed out in one of her lucid essays, the undoubted effects of the serious disturbance of the psyche of simple men when they separate themselves from the background and traditions of their fathers.

The general problem of homicide in New York and in the country as a whole is most complicated and the causative factors are many. In the opinion of certain students, among them that fine scholar and noble visionary, Peter Kropotkin, the homicide rate is a function of climate. Others argue for or against capital punishment. The fact that the homicide rates in the forty American states that have capital punishment on their statutes are not convincingly lower than the rates of the eight states where murderers are not executed, gives support to the proponents of more humane punishment. The abolition of legal executions, however, does not in itself eliminate murder.

Another proposal: greater power to the police authorities. In a recently published murder story, with an English setting, the hero champions the continuation of capital punishment and as an unanswerable argument he finally exclaims, "Why, if we abolish capital punishment we shall have to arm our police!" In this country, with our city and state police practically on a war footing, there has been no perceptible downward trend in the homicide rate. In New York State, for example, the rate in 1907 was 4.4 per 100,000 population; in 1932, it was 4.6. In the course of these twenty-six years the rate fell below 4 only three times: in 1908 (3.7), 1909 (3.2), and 1918 (3.8—only civilian deaths).

No sane person opposes the legislation that is now being urged upon the state and federal authorities for a uniformly rigid control of the

sale of firearms. There can also be no objection to reforms which would make it impossible for wealthy offenders to circumambulate for years through the maze of our archaic judicial procedures.

It would be, however, naive to hope that the mere enactment of model prohibitory and regulatory laws would solve our crime problem. The adage that "a people cannot be legislated into righteousness" is founded upon the solid basis of universal experience. In our opinion, the excessive lawlessness of this country is the result, not of somatic, but of spiritual disorders of the social organism, and a permanent cure must be sought along psychological, not physical lines. It is essential to keep in the forefront the fact that the virus of crime has spread horizontally through all social strata, and that only too many of our officials and persons in quasi-public positions of trust, high and low, have been openly branded as active or "silent" partners of thieves and murderers, and, what is most significant, that the reaction on the part of the bulk of the electorate to such recurrent disclosures has been that of indifference or innocent merriment. In a condition of such general metastasis, surgery alone would do but little good.

Things will begin to mend only as an ever increasing proportion of our people become intellectually honest, not because it is "the best policy," but because they will feel the need of possessing this moral quality, *an und für sich.*

In a recently published notable essay, "The Struggle for Intellectual Integrity"(12), Professor Bridgman gave his conception of the etiology of the disease which is now afflicting our social life: the growing prevalence of scientific disciplines and the popular dissemination of the results of scientific inquiry had as the first, and inevitable, reaction a complete repudiation by honest thinkers of many of the previously accepted precepts and ideas; then followed a period of doubts and uncertainties, through which we are still passing; the mass of the people, left without authoritative guidance, have submitted to the unthinking, but aggressive elements in the community. Thus, "it appears fairly evident that the incidence upon the human race of a passion for the practice of intellectual honesty must at first be entirely negative and destructive in its social results. . . . From the point of view of an external observer the whole community is drifting and floundering." In Professor Bridgman's opinion, the apparent decline in our social morals is "the necessary prerequisite to a general advance." Although, so far, "not . . . more than a small fraction have caught the vision [of intellectual integrity] . . . enough have caught it to be appreciably effective . . . [and] a new leaven is working in society."

This diagnosis, going beyond the ever-changing pattern of symptoms, states what we believe to be the fundamental cause of our crime

situation. Since a lasting cure is directly dependent upon a widespread acceptance of the ideal of personal and group intellectual integrity, it cannot be brought about in a year or a dozen years—perhaps not "in the lifetime of any of us." With the progressive increase in the number of healthy cells in our social body, the morbid processes should be gradually brought under control.

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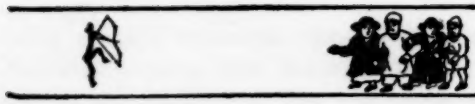

NEUROPATHOLOGY AND THE INTERNAL ENVIRONMENT*

A STUDY OF THE NEUROMUSCULAR FACTORS IN ATTENTION AND THEIR BEARING UPON MAN'S DISORDERS OF ADAPTATION

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I.

MEDICINE, like other sciences, had its beginning in the metaphor, the symbol, the allegory. Astronomy was first symbolized in the teachings of astrology. Modern chemistry was presaged in the figurative doctrines of the alchemists, and in man's early theological formulations there is found the original allegorical treatment of the humanitarian sciences. As science developed, this tendency to the use of metonymy and the symbol came more and more to smack of phantasy and charlatanism, until gradually rhetorical usage gave way to concepts based upon more substantial structural denominators. Thus it may be said that science has been a record of man's progress from symbol and allegory to demonstrable structures and functions as exemplified in the objective findings of the laboratory.[1]

The present discussion, based upon laboratory observations, is an attempt to relinquish prevailing figurative, symbolic or psychic interpretations of behavior-phenomena and to study the structure and function of man's organism in its immediate relation to the environment. In this

* This paper was read at the Twenty-third Annual Meeting of the American Psychopathological Association, Washington, D. C., May 11, 1933 and will form a chapter of a book soon to be published.

[1] "As a realist the scientific man recognizes that the 'real things' with which he deals as chemist, as microscopist and as practical man are incomplete fragments of, or perhaps merely symbolic expressions for, the underlying intrinsic realities." Herrick, C. Judson, "The Limitations of Science," *The Journal of Philosophy*, March 28, 1929, Vol. XXVI, No. 7, pp. 186-188.

bionomic study of man it will be my effort to regard the behavior of the organism in respect to the environment from the same ecological basis from which we would study the behavior of the amphioxus or paramecium in relation to its habitat. In studying the behavior of these lower organisms, however, a circumstance which we commonly overlook is that we necessarily study them only from the outside. We acquaint ourselves with their structure and function only through the data we gather or through the impressions we form of them by means of the external senses. We gain no first-hand, inside knowledge of these remote forms of life through our own empathic or proprioceptive experience. How it feels to be a paramecium, or even an organism of much closer kin to us, we have long ago forgotten, and can therefore approach such organisms now only through the medium of our outer, projective senses. It is true that there are likewise in man many structures and functions which may be observed and recorded only through the avenues of the special senses, but there are also within the organism of man certain behavior-processes which are quite inaccessible to the exteroceptive system or to the projective senses. We may become acquainted with these behavior-reactions only as we ourselves are the inside proprietors of such processes—only as we ourselves embody in our own organisms the living repository of sensations and impulses that make up the internal environment of man.

In attempting to orient ourselves in regard to what has been for me an entirely new field of investigation, it would seem simpler in dealing with this field of man's bio-physical relations first to consider the sphere of man's ecology as it is effected through the external senses or through the medium of the idea. This field of the idea, the symbol or mental image, is of primary importance to the neurologist and the psychopathologist because of the many impediments in man's adaptation which are associated with images or ideas as they mediate between the organism and the outlying world through the special external senses.

Medicine has long recognized the wide domain of disorders described as impairments in the sphere of the idea or the image—the sphere of what are called mental disorders.[2] It has long recognized the conflicts

[2] How wide a domain this is may be judged by recent figures presented by the Council on Medical Education and Hospitals of the American Medical Association. According to their report published in *The Journal of the American Medical Association* for March 25, 1933, "The largest number of special hospitals consists of those for nervous and mental patients. . . . . In capacity and patient population they represent nearly 50 per cent of the total."

and discrepancies, the educational immaturities and the retardations of development in the life of man that centre around his thoughts and his ideas.[3] I should like, therefore, in this study first to direct our inquiry to this sphere of adaptation that has to do with the image or idea because of the relation between distortions occurring in this sphere and the wide domain of mental disorders as now envisioned by psychiatry.[4]

II.

In the year 1895 Freud drew the attention of the medical world to a phenomenon which he had observed in his study of mentally disturbed patients—a phenomenon which up to that time had remained unnoted.[5] He drew attention to the connection in these patients between the idea, the image or symbol entertained by them and the coincident emotion or affect that invariably accompanied it. This apparent amalgamation between symbol and affect observable in psychic disturbances became the pivotal point in the therapeutic system of psychoanalysis. Indeed it was this discovery of Freud's in the sphere of adaptation having to do with the image or idea through which psychiatry secured for the

[3] The department of behavior which Franz Alexander has aptly termed the individual's "foreign politics" is synonymous with this sphere of the image or idea. ("Functional Disturbances of Psychogenic Nature," *The Journal of the American Medical Association*, February 18, 1933, Vol. 100, pp. 469-473.)

[4] A paper by Bertram D. Lewin, M. D., "The Body as Phallus" (*The Psychoanalytic Quarterly*, 1932, Vol. II, pp. 24-47) describes the very acme of symbolic distortion as evidenced in the neurotic's recourse to metaphor and allegory. It shows also the thorough systematization of principles elaborated by psychiatry in its efforts to keep pace with the infinite diversions of figure, symbol and metaphor characteristic of neurotic disorders. Freud is of course outstanding in his interpretation of the symbolic symptomatology of these manifestations. But the painstaking and able writings of other students in the field of psychiatry show also the many varied ramifications and concatenations characteristic of these projicient processes. In this country alone one has only to cite the valuable formulations of such thoughtful investigators as White, Meyer, Paton, Campbell, Brill, Wertham, Schilder, Jelliffe, Sullivan, Clark, Bender, Williams and a host of others to indicate how fully the field of man's subjective projections has been studied and described.

[5] Freud, Sigmund, *Selected Papers on Hysteria and other Psychoneuroses*, translated by A. A. Brill, New York, The Journal of Nervous and Mental Disease Publishing Co., 1912.

first time an entering wedge to an understanding of neurotic disorders and insanity.[6]

As we know, Freud recognized also in this association between symbol and affect a purposive and insistent character. He found that these two elements adhered to one another with a consistency which gave indication of a definite intentional import.[7] It was this discovery which led to the characterization of Freud's teaching as the *dynamic* interpretation of the neuroses and of his system as that of dynamic psychology.[8] For Freud soon saw that this affiliation between the image and the affect embodied the entire desire-life of the neurotic patient, and because of this dynamic association between image and affect he gave to this phenomenon the name of *wish-fulfillment*.[9]

All this is so commonplace now in the history of psychoanalysis as to have become legendary.[10] But it is important to recall this quite general emphasis upon the image or idea with its accompanying affect because of its connection historically with the following description of a biophysical experiment that directed itself to the study of man in his immediate behavior-reactions.[11] This group or total-reaction experiment

[6] The association between idea and affect is in fact the basis of the reaction Freud first noted as the "transference"; the coterminousness of these two elements underlies also the significance of the "social image" as first isolated in our early group studies. See "Social Images versus Reality," *The Journal of Abnormal Psychology and Social Psychology*, October-December, 1924, Vol. XIX, No. 3, pp. 230-235 and "Our Mass Neurosis," *The Psychological Bulletin*, June 1926, Vol. 23, No. 6, pp. 305-312.

[7] In this purposive or teleological import we again see indications reminiscent of metaphysics and of magic. We will recall that the element of import and intention in neurotic processes was originally ascribed to some allegorical agent existing outside the patient. Hysteria and kindred disorders were interpreted as visitations from heaven in retaliation for the wilful transgression of the unfortunate individual. Today allegorical causation and symbol have been shifted by psychiatry to the patient himself, so that the causal or moral agent in the production of his disorder is, in the interpretation of psychiatry, now traceable to his own psychic or symbolic processes.

[8] MacCurdy, John T., *Problems in Dynamic Psychology*, New York, The Macmillan Co., 1922.

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[9] Freud, Sigmund, *Die Traumdeutung*, Leipzig und Wien, Franz Deuticke, 1900.

[10] *Psycho-Analysis Today*, edited by Sandor Lorand, New York, Covici-Friede, 1933.

[11] Galt, William, *Phyloanalysis—A Study in the Group or Phyletic Method of Behavior-Analysis*, Psyche Miniatures, Kegan Paul, Trench, Trubner & Co., London, 1933.

originally set out from the invariable association in neurotic patients between the affect and the idea, and, as the logical extension socially of this early discovery of Freud's, it concerned itself with those bionomic processes which reflect the biology of man's organism in its internal, proprioceptive function.

III.

The early phase of this experiment brought out several interesting observations.[12] Outstanding among them was the observation that this dynamic connection between the affect and the image, noted by Freud in the unconscious processes of the mental patient, is present equally in the processes of normal individuals. The persistent and obsessive presence of this dynamic couplet, namely, the idea and its inseparable consort, the affect, was found to exist everywhere and at all times throughout the community life. It is present not only under special or abnormal circumstances, but it is present and operative under conditions of ordinary social intercourse. Because of the universality of this attachment between the idea and the affect, it became apparent that in dealing with this phenomenon first described by Freud we were dealing not with a sporadic clinical symptom but with an indigenous phyletic condition. It became evident that in normal communities of man, individuals are constantly liable to mental aberration or to disorders of adaptation due to this unrecognized cohesion between emotion and idea. This means that presumably normal individuals are at all times subject to the incidence of mental disease. It means that among normal

[12] The preliminary findings in the group or total-reaction experiment have been fully reported in other papers by the author:

"The Laboratory Method in Psychoanalysis," *The American Journal of Psychiatry*, January 1926, Vol. V, No. 3, pp. 345-355.

"The Reabsorbed Affect and its Elimination," *The British Journal of Medical Psychology*, 1926, Vol. VI, Part 3, pp. 211-218.

"The Autonomy of the 'I' from the Standpoint of Group Analysis," *Psyche* (London), January 1928, No. 31, pp. 35-50.

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See also: Syz, Hans, "On a Social Approach to Neurotic Conditions," *The Journal of Nervous and Mental Disease*, December 1927, Vol. 66, No. 6, pp. 601-615 and "Socio-Individual Principles in Psychopathology," *The British Journal of Medical Psychology*, 1931, Vol. X, No. 4, pp. 329-343.

communities there may occur at any time a sudden flare-up of emotional stresses which can be traced to this wayward and unpredictable interconnection between the individual's affect and his mental image or idea.[13]

Another and equally arresting observation regarding this unconscious linking of the idea and the affect was its completely impregnable position. All recourse to ordinary mental procedures proved utterly incompetent to cope with this securely intrenched "association" between the affect and the idea. As far as this essential juxtaposition between image and affect was concerned, repeated experiment showed this ancient and venerable alliance to be completely inaccessible to every conceivable avenue of external approach.[14]

With this brief review we may leave the sphere of inquiry that has to do with the idea or the image. We may dismiss all consideration of those factors which bear upon the sphere of mental and nervous disorders as these maladjustments are reflected in the outer symptomatology of the affect and the idea. For now, as we continued the group or total-reaction experiment with a view to discovering some means of dissolving this rigid pact between the idea and the affect, it became evident that what appeared to constitute the seat of the trouble—this adhesion uniting the affect and the idea and about which there has always been so much ado—was not the actual disorder at all. It was found that, despite prevailing figurative, symbolic or psychic interpretations, the real difficulty had nothing whatever to do with processes that are observable by means of the special projective senses. Coin-

[13] Among the predisposing factors in such a sudden flare-up are, of course, a patient's lowered physical resistance, the presence of some constitutional weakness or accidental infection, conditions of unusual economic stress and kindred factors.

[14] It was, of course, not difficult to cause the affect to shift from one idea to another or to distribute itself socially among several ideas, just as in the treatment of the neurotic patient through the method of psychoanalysis or other psychotherapeutic technique it is not difficult to shift an affect from one idea or cluster of ideas to others and thus to give to it a social distribution that may render it temporarily quite harmless. But this is a commonplace. In dealing with children all of us have recourse to such handy expedients. We all know instinctively how easy it is to dissipate an affect-crisis by "diverting a child's interest," as we say. In the clinical field the outstanding instance of this shift of affect may be seen in the spontaneous alteration of mood from elation to depression that characterizes manic-depressive insanity. In its wider social expressions it is seen in those broad waves of affect which periodically pass over nations and disclose themselves in the feeling-alternations of peace and war.

cidently it became evident that the real conflict lay in the organism's internal, proprioceptive processes; that alterations involving conflict within the internal body-processes were answerable for the difficulties and embarrassments which until now we had been ascribing to the sphere of the idea or the image. This complete shift of the field of inquiry from the sphere that has to do with the symbol or idea to the sphere that has to do with internally perceptible body-processes marked the introduction of studies in phylopathology or the adoption of proprioceptive principles of investigation based upon a study of man's adaptation as a physiological process.[15]

IV.

It is, I think, accepted by most of us today that the process of attention or ideation consists of an internal adjustment of the organism to the external environment, and that this adjustment to outer environment is dependent upon certain definite motor patterns of alteration within the organism's neuromuscular system.[16] In the present discussion I should like to give special consideration to the domain of these internally appreciable alterations in the neuromuscular system concomitant to the organism's attentional set or focus as it relates the organism to the outer environment. For these neuromuscular alterations which are the physiological concomitants to the process of attention have, in our total-reaction experiments, entirely replaced all consideration of the process of man's attention or adaptation from the standpoint of the mentally projected idea or image. These motor concomitants, in so far as they are internally appreciable, are then the sole materials of investigation in the present study. It will, however,

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[15] Burrow, Trigant, "The Morphology of Insanity as a Racial Process—A Study of Attention in Relation to Adaptive Disorders," *The British Journal of Medical Psychology*, 1933, Vol. XIII, pp. 296-312.

[16] Among the outstanding advocates of the motor basis of attention may be mentioned Darwin, Bell, Alexander Bain, William James, Theodore Ribot and Hugo Münsterberg. An excellent summary of this trend has recently been given by Professor Herbert S. Langfeld in his article, "The Historical Development of Response Psychology," *Science*, March 10, 1933, Vol. 77, pp. 243-250.

For more recent evidence of the concomitance between attentional processes and neuromuscular changes the reader is referred to the experimental studies of Edmund Jacobson. "Electrophysiology of Mental Activities," *The American Journal of Psychology*, October 1932, Vol. XLIV, pp. 677-694. See also Schultz, J. H., *Das autogene Training*, Leipzig, Georg Thieme Verlag, 1932.

materially assist our understanding of just what happened in the course of our investigations as they concern this shift from the customary sphere of the idea or image to the sphere of the organism's internal processes, if we will consider briefly the morphological structures whose functional alterations constitute the material under investigation. In order to do this it will be necessary to review for a moment certain early biological foundations that bear upon the general ecology of man as a living organism.[17]

As we know, man's bionomic relation to the world of objects around him is effected through the various superficial sense-organs occupying the periphery of his organism. It is through the medium of the periphery with its external senses that the organism is related to the external world of phenomena.[18] The peripheral senses which in man have come to be especially employed in mediating between his organism and the external world are the special external senses located in the head, chiefly the visual and auditory senses. But in the course of man's evolution something very special happened in the domain of these cephalic senses. By virtue of a particular function these special sense-organs located in the cranial segment acquired secondarily a reciprocal action in relation to one another which quite differentiated them in their relation to the function of the periphery as a whole.[19] This circumscribed, partitive function corresponds to the condition which, in a different connection, has been described by Coghill as a partial reaction-pattern.[20]

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[17] The present thesis is a further reiteration of my effort to extend the conception of neuro-morphological processes to include their phyletic and evolutionary growth from a unitary racial stem, and it has seemed entirely appropriate here, as in similar discussions of mine, to employ the same terminology that is now habitually used in the study of the more static or restricted morphological process. Whether we are dealing with the neural organization of the individual man or with the neural organization of the genus man, the structures under consideration are still neural, and the basis from which these structures are studied is still morphological, notwithstanding that the change in function, which the morphological alteration involves, covers a period of man's development that extends over many thousands of generations. (Cf. Wheeler, W. Morton, *Emergent Evolution*, Psyche Miniatures, Kegan Paul, Trench, Trubner & Co., London.)

[18] Richet, Charles, *Essai de Psychologie Générale*, Librairie Félix Alcan, Paris, onzième édition, 1930, p. 91.

[19] Burrow, Trigant, *The Structure of Insanity—A Study in Phylopathology*, Psyche Miniatures, London, Kegan Paul, Trench, Trubner & Co., 1932.

[20] Coghill, George E., "The Early Development of Behavior in Amblystoma and

This restricted pattern of reaction associated with a special function of the external senses located in the head will be given very particular emphasis in the present inquiry. I shall try to show that the function of this area has become quite demarcated from the general peripheral function that determines man's total attentional adaptation in relation to the external environment. For through their coördination with the organs of speech these special external senses, in relating man's organism to the outer world, do not now function so much as integral constituents of the total periphery, but function rather through their special and circumscribed mechanism of projection. This projicient function, represented in the special neuro-semiotic or picture-forming mechanism of man, is the exclusive function of the exteroceptive segment as it operates in the production of the image, the symbol or the idea, and it is this exteroceptive segment that constitutes the physiological substrate of that particular mode of attention which has to do with mental concepts or with the language of man and with his ideas. This medium of connection existing between the organism and the external environment through the symbol or idea covers an enormously wide domain of man's experience. The sphere of attention or adaptation that is restricted to the special projective senses through their formation of the image or idea represents for civilized man today practically the entire field of the organism's bionomic interconnections with the external world of actuality.

Prior to the development of language, however, or prior to the introduction of the type of attention that mediates contact between the organism and the environment through the "invention" of the symbol or idea, there existed of course in man, as in other animals, a type of attention or adaptation through which the organism reacted directly and as a whole to the external environment about it. That is, the process of attention was accomplished as a total reaction-pattern and related the organism to the environment as a total pattern of response. This total response was accomplished through the mediatory action of the periphery in its total undifferentiated function. While it was con-

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in Man," *Archives of Neurology and Psychiatry,* May 1929, Vol. 21, No. 5, pp. 989-1009.

————, "Individuation versus Integration in the Development of Behavior," *The Journal of General Psychology,* 1930, Vol. 3, pp. 431-435.

————, "The Biologic Basis of Conflict in Behavior," *The Psychoanalytic Review,* January 1933, Vol. XX, No. 1, pp. 1-4.

tributed to in part also by the special senses of the head, this local function was originally performed always in coördination with the periphery's total intermediary function.

With reference to the periphery let me recall that from the lowest unicellular organism, with its inner protoplasmic contents and its delimiting cell membrane, to the highest differentiation of structure observable in the primates, there is throughout the evolutionary series an unbroken line or lamina of demarcation between the organism's internal and its external environment. It is precisely this phyletic lamina that constitutes the organism's periphery.[21] In the implications of the present thesis it should not be overlooked that the function of the periphery in man, as in other organisms, is primarily that of mediating between the organism's internal and its external environment. The periphery, therefore, with its external senses possesses not only the function of establishing contact with the external environment, but it possesses also the function through which it makes internal contact with the internal environment. In short, the organism's periphery represents the general go-between through which there is established contact and communication between the total internal environment of man and the total external environment lying outside of his organism.

By the internal environment I mean the domain which includes the highly sensitive, mobile structures enclosed within the body's outer crust or periphery and which constitutes the vascular, visceral, glandular and involuntary muscular systems with their intricate ramification of tissues supplied from the sympathetic or autonomic nervous system. This domain is closely related in its function as a whole to the *"milieu intérieur"* described by Claude Bernard, Haldane and Cannon; it has been given very special study by Kempf and many others.[22]

When I speak of the periphery, however, it is extremely important that I make clear the morphological significance of this sphere as it mediates man's general bionomic adaptation. The periphery, as the term is here used, refers to all those external body-processes through

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[21] I hope I do not appear to entertain the idea that in the more highly organized forms of life there exists anatomically any such sharp demarcation between the periphery and the internal organization as may be made out in unicellular organisms between the cell membrane and its inner protoplasmic contents.

[22] Kempf, Edward J., *The Autonomic Functions and the Personality*, Nervous and Mental Disease Monograph Series, No. 28, 1918.

Cannon, Walter B., *The Wisdom of the Body*, New York, W. W. Norton & Co., 1932.

which the organism reacts to the surrounding environment. In this sense the periphery includes not only the dermal structures with their tactile and other special sense-organs, but it includes also those external skeletal muscles through whose kinesthetic function the organism establishes its relation spatially to the surrounding environment. The periphery, then, as here defined, includes also that portion of the total organism which in general is controlled by the voluntary muscles and innervated by the cerebrospinal nervous system.

When we come to take a comprehensive view of man's bionomic position in the universe—when we come to view broadly the field of man's mental and social interrelationships, and especially when we consider those processes which are marked by difficulty and impairment as we meet them in the sphere of mental disorders—we shall find that we have as yet been occupied with this ecological relation in respect only to the part-function of the periphery I described a moment ago as the projective function of the exteroceptive segment. We shall find that we have been occupied with this part-function of the periphery only as it concerns the sphere of attention or adaptation that has to do with the image or idea. For upon investigating the organism's bionomic adaptation as a whole, there is evidence that the organism now attempts to adjust its behavior entirely through this medium of the idea; that, due to man's more recent cerebral development, the social reaction of the organism to the external environment has been negotiated solely through this part-function of the exteroceptive segment. In brief, we have been occupied only with that part or function of man's periphery which relates him to the external environment through the symbol-forming system of reactions located in the head, and accordingly we have attempted to cope with the invalidations and impairments in man's adaptation only on this wholly specialized projective basis of man's relation to the universe.[28]

There is strong internal evidence that prevailing descriptions of man's adaptation to the external environment and to others of his own species, as it is mediated through the image or idea now projected by him, have failed to include the general kinesthetic function associated

[28] "'Psychotherapy,' said Grasset, 'is the treatment of diseases by psychic means, that is to say, by persuasion, emotion, suggestion, distraction, faith, preaching, in a word by thought.'" *Revue des Deux Mondes,* September 15, 1905, p. 351. Quoted by Pierre Janet, *Psychological Healing,* Macmillan & Co., 1925, Vol. II, p. 1207.

with the peripheral neuromuscular system in orienting the total organism's relation to the external world. When we come to consider the problem of nervous disorders and insanity from a phyletic basis of inquiry, it appears that this failure in man's general bionomic adjustment is answerable in no small measure for the wide-spread evidence of unreality and illusion as they exist in the individual and in society. For, in the adaptation of the total organism, the periphery, as I have said, includes both the special senses of the head and the entire skeletal musculature underlying the general body surface. But it does more than this. It includes also the kinesthetic correlation that unites the function of the general body musculature and the extremely important muscular function of these special exteroceptive sense-organs.

From investigations of total-reaction processes, it would seem that, in the field of man's symbolic attention or in his projicient adaptation, the organism has inadvertently substituted a preponderantly partial reaction-system in place of the organism's total pattern of response, and it is due to this generic maladaptation within man himself that he has failed as yet to acquire an aptitude for sensing processes which are connected with a mode of adaptation that is internal to his organism as a whole. He has failed to reckon with processes which call for directive adaptation and control but which at the same time are not approachable through the usual avenues of the external senses and the idea. These are the processes to which I alluded in the beginning of this paper as belonging to the internal proprioceptive function of the organism.

V.

To return to a consideration of the altered direction of inquiry necessitated by the group or the total-reaction experiment, I was speaking of the complete impasse we found ourselves faced with in our efforts to separate the idea and its invariable attendant, the affect. I said that the seat of the trouble did not, after all, lie within this mental or projective sphere. I also alluded to the fact that the field of our inquiry had shifted from the sphere of the idea to the sphere of the organism's internal proprioceptive processes.

Following our brief review of the function of the periphery as intermediary between the internal and external environments, we are better prepared to consider the process of attention in the light of the general neural and muscular alterations which are its motor con-

comitants. We are better prepared to consider those internal modifications which are ordinarily neglected in our customary preoccupation with the outward manifestation of the idea and its adherent affect. In the altered trend which the inquiry now took the direction of our interest was wholly different. Instead of directing itself outward to the image as projected through the medium of the external senses, the course of the investigation became automatically reversed. The attention was now directed inward upon the organism with its generally distributed body tensions, both internal and peripheral, but specifically to that part or detail of the periphery that constitutes the cephalic or exteroceptive segment.

We are now speaking, therefore, of the process of attention or adaptation as internally appreciable in those motor alterations which are concomitant to the process of attention in its outer manifestations—manifestations which may be either partitively projected in the form of the symbol or idea, or which may be expressed in the organism's total response to the outer environment. But whether total or partial we have here to do only with reactions that are perceptible within the organism as definite neural patterns of response. It is extremely important to note the emphasis here upon the function of attention as an internal neural process in contrast to the habitual emphasis upon a process that is connected with the outer concept or image. The physiological pattern corresponding to the partial, specialized, projective pattern of attention with its specifically congested tension and stress in the region of the brow and eyes was from now on sharply differentiated from the pattern involved in the integral, empathic system of attention with its harmonious distribution of tensions throughout the organism as a whole. This distinction between the general neuromuscular pattern of attention and the projective reaction expressed in the organism's symbolic or neuro-semiotic behavior is basic in the present thesis. For with the organism's concentration upon this physiological pattern localized in the exteroceptive system, the tensions and alterations belonging to the two physiologically appreciable types of attention—the interoceptive and the exteroceptive—became clearly demarcated within the body structures.

Instead of the attention now centering upon the projected idea and its adherent affect, the entire attentional focus of the organism was shifted. This meant that a pattern of attention was called into play which was wholly different from the attentional pattern that connects

a part-function of the periphery with the external environment through the symbol or idea. The specific motor alterations which are the accompaniment of the process of attention having to do with the projected image or idea—motor alterations which are definitely perceptible in neuromuscular tensions and strains associated with the exteroceptive segment—were now replaced by neuromuscular tensions and alterations which centered in the organism's proprioceptive processes. Because of this physiological discrimination in attentional patterns; that is, because of this altered focus of attention and its concomitantly altered physiological pattern within the organism, there was a two-fold result: It became possible from now forward for the projective segment to report its object quite mechanically without in the least involving the sensations or affects belonging to the sympathetic or autonomic responses of the internal environment; and further, coincident with the separation of the exteroceptive function from that of the empathic or autonomic system, the affect-tensions which hitherto were obtruded into the cephalic segment now became dissipated in sensations and feelings belonging to the organism as a whole. Accordingly, the conflict produced through the projection of the affect into the sphere of the idea automatically disappeared. There was now no longer the affect adhering to the idea.

As a concrete illustration of such a shift of tension, let us take the frequent experience in which one projects his feelings outward toward some one else, and accordingly "sees" some one as meritorious or reprehensible. Say the projection has to do with some latent residue of irritation. Now if the individual succeeds in his recourse to a more internal concentration, he immediately shuts out entirely all affect-preoccupation with the offending person or event. Automatically his interest or concentration now becomes focussed within himself and centres specifically upon hitherto unobserved local tensions in the region of the head, principally in the eyes and brow—a sensation concomitant to the individual's customary affect-symbolizations or projections. Correspondingly, of course, if there is the inadvertent admission again of the affect-image to the field of attention, there automatically ceases this experience of local tension in the exteroceptive area, and again the irritation with the person opposite becomes "real" in accord with one's projective preoccupation with him. But with consistent emphasis upon strains and tensions that are internal to the tissues, these strains and tensions are finally resolved. For they are gradually recognized as

conditions which are not native to the organism but which are extraneous burdens resulting from the affect-images it has become reflexly one's habit to project. With continued attention in this direction one finally senses that within his own body-processes there are strains and tensions which, while alien to his organism, are yet present within him, and that in his projective preoccupations he had hitherto concealed them beneath his "irritation" with the person in question. With the application of this technique one becomes sufficiently fortified in his own experience to accept at its face value the pain and tension which has been all along registered in his own organism but only now recognized, and no matter how often the old tricks of habit lead him to this hallucinatory projection of affects, he now knows that the basic cause of his irritation has to do with a disorder that resides in his own physiology.

That there are objectionable people in the world, people who because of their ignorance, their undependableness, their uncouth habits or their lack of personal hygiene, are not acceptable, is not to be denied. But a calm contemplation of such personalities as undesirable and a consistent avoidance of contact with them is one thing, and a moralistic attitude of criticism and retaliation toward them is quite another. In the one case one is dealing with an objective reality and in the other with an hallucinatory affect that is purely subjective and pathological.

The importance of this objective approach in dealing with the symptoms or affect-projections now registered in disordered mental states is obvious. It has the immediate merit of bringing such disorders within the legitimate field of medicine. Through this altered technique a patient is no longer required to trace his mental "associations." He is not required to search his ideas in order to discover the obstructive affects that are attached to them. He needs only to discover that the projective attentional process located in his head has assumed the function of negotiating neuromuscular tensions and alterations which belong to the organism's internal, empathic system of reactions and that accordingly his task is gradually to acquaint himself with a bionomic technique that will permit him to shift the habitual trend of his internal tensions.

Let us consider two typical illustrations of the neurotic or, as I prefer to call it, the semiopathic or affect-projecting reaction. In the first instance the affect-picture is, let us say, unpleasant. It is a question of something the patient does not like. He is resentful and excited, or he may even be quite obsessed and he wants something done about it.

But he wants something done about it by some one outside of himself. He complains, he is dependent, the responsibility for his dissatisfaction is, according to his habitual feeling, in some person or condition that lies outside of him.[24] Perhaps he does not receive the love or attention or recognition he considers, or mentally "feels," to be his due. Maybe he feels that he lacks some comfort or economic security to which he is entitled, or that he has lost the affection of some relative or friend. Here again, being occupied merely with ideas and images, he senses his discomfort as residing in some condition outside of himself. That is, it presents itself to him as lying along the path of his projective, exteroceptive experience, and consequently he looks constantly outside of himself for its adjustment. From the patient's projective basis it is impossible for him to do other than look for relief in some form of projective remedy. And so he forever continues to pursue this will-o'-the-wisp that consists merely of the linked idea and affect which he himself has projected.[25]

In the second instance, perhaps the image-obsession that occupies the patient is highly satisfactory to him. Perhaps he has what he wants

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[24] Consider the marked emphasis psychiatry places upon the affective picture-reaction when it describes delusions of reference and ideas of persecution characteristic of paranoid states.

Compare Charles Richet, *Essai de Psychologie Générale*, Librairie Félix Alcan, Paris, 1930, p. 137. "En somme, les sensations que notre corps physique donne au *moi* ne fournissent que des notions très vague, et c'est surtout au point de vue de l'émotion qu'elles ont de l'importance.

"Les sensations avec émotion sont nombreuses, et on peut les ranger en deux classes, suivant que l'émotion est accompagnée d'attrait ou de répulsion, de plaisir ou de douleur.

"Malgré la très grande diversité des sentiments, dont les nuances sont infiniment variables, et quoique cette diversité aille souvent jusqu'à la contradiction, on peut dire que tous les sentiments reviennent à être en définitive plaisir ou peine, attrait ou répulsion, bien-être ou mal-être.

"Cette émotion de l'organisme dépend non des objets eux-mêmes, mais de l'organisme récepteur. Les forces extérieures agissant sur nous sont impassibles; nulle qualité, bonne ou mauvaise, n'est en elles. L'amertume n'existe pas plus dans la noix vomique que la douleur dans le tranchant d'un couteau."

[25] Burrow, Trigant, "So-called 'Normal' Social Relationships Expressed in the Individual and the Group, and their Bearing on the Problems of Neurotic Disharmonies," *The American Journal of Psychiatry*, 1930, Vol. X, No. 1, pp. 101-116.

in the loved object before him.[26] But here too, as with the unpleasant or hated object, it is the projicient path of reaction with which the patient is preoccupied. Again the patient constantly projects his goal, he constantly "sees" his loved object in the form of a mere affect-image. So that, paradoxically, he is ever beset with possessive claims upon it. As with the unpleasant image, so here he claims a proprietary right in respect to it. In this way his aim becomes automatically retroactive. Being, through organic necessity, ever driven to reclaim his own projected feeling—a feeling which really exists internal to him—and not knowing, in his now preponderantly semiotic adaptation, how to do this, he can only seek blindly for compensation in the relentless urge to possess, to have control of, and to legislate over his so-called loved object. Here is provided a fertile soil for the development of disordered reactions within the empathic system—for jealousy, self-doubt, competition, suspicion, irritability and all the many self-defeating emotions which commonly adhere to the idea. Under these conditions the patient builds up phantasy upon phantasy, phobia upon phobia, delusion upon delusion. There are no limits to his sick logic, such are the lengths to which his wayward fancies carry him. On the other hand, in response to a bionomic technique that is based upon a patient's total-attentional reaction, one observes in each of these instances the complete change in the personality as the patient learns to shift the weight of his interest from the affect-symbol or picture presented before him to the internal, tensional state of his own organism.

Where the patient has learned to retain the image but dismiss the deterrent affect that clings to it, he becomes an organically self-possessed personality. In his relation to himself and to others he achieves a self-reliance that is internal and organic. That is, he achieves a reliance upon the self which he senses within his own tissues and organs. This makes for an integral, self-contained reaction-type in contrast to a divisive, scattered and outwardly dependent type of reaction. For in this shift of the patient's neuromuscular adjustment to a total internal pattern of attention, he has assumed a bionomic relation to his surroundings which is synonymous with the health or wholeness of the organism.

One cannot sufficiently emphasize the social nature of the aberrant mechanism involved in the individual's affect-projection. Though it is

[26] Burrow, Trigant, *The Social Basis of Consciousness—A Study in Organic Psychology,* International Library of Psychology, Philosophy and Scientific Method, London, Kegan Paul, Trench, Trubner & Co.; New York, Harcourt, Brace & Co., 1927, p. 78.

a physiological condition that affects the individual organism, the condition represents an organic adjustment through which the individuals of the species make contact with one another socially. Where inter-individual contact rests upon an aberrant process within the organism of each individual, there results necessarily an inter-individual or social organization whose processes are characterized by aberration. It is hardly necessary to say that the effect of this socialized aberration in producing such wide-spread reactions as war is incalculable. But it is not to be expected, of course, that war and the long line of socialized forms of disordered affect will be understood by man as reflections of aberrant processes within his own organism, in the absence of a medical and biological recognition of the phylogenetic basis of affect-disorders in general. Thus medicine is confronted with a challenge and an obligation that is not only social but scientific, for until the progress of our cultural evolution permits us to sense the phylogenetic and intrinsic nature of our disorders of adaptation, both individual and social, medicine can only continue to regard these manifestations as separate and esoteric conditions peculiar to each individual. And, accordingly, medicine must continue its fallacious attempts to remedy the condition with measures that are equally separate, localized and esoteric. With the acceptance, however, of a basis of observation that is broadly physiological and phylogenetic, our affect-disorders, individual and social, national and international, including war and similar disruptive expressions of the social organism, will come to be regarded as spasmodic reactions analogous to the infective processes which occur from time to time throughout the community in the form of epidemics.

VI.

There is really nothing novel about an approach to man's bionomic adaptation which proceeds from a basis that takes into account the internal organism and its periphery as a whole. Such internal measures of the organism's behavior are a part of its every-day adjustment to the environment and, as a matter of fact, far antedate biologically the organism's adjustment to external conditions through the avenues of the external senses or the idea. Even so apparently simple a process as walking is, in truth, one of the most difficult and complicated mechanisms which man has ever mastered. But such general bodily adjustments are not learned through the function of the exteroceptive senses. They are acquired only through an acquaintance with one's organism

that is dependent upon one's intrinsic sense of the balances and tensions that control the neuromuscular apparatus as a whole. What is lacking in man's general orientation is an internal appreciation of these processes in relation to man's disorders of adaptation that will allow of their directive systematization and control.[27]

Because of its picture-forming mechanism we may call the cerebral reaction-zone the graphonomic or graphogenic system. In contrast to this local graphonomic system, the general bionomic system of adaptation may be known as the stereonomic or stereogenic system. The functions which belong to the stereonomic system may be measured and adjusted only through the recultivation and training of those kinesthetic or stereonomic processes that have to do with the adaptation of the total internal environment to the total external environment through the medium of the total periphery.[28]

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[27] Burrow, Trigant, "A Phylogenetic Study of Insanity in its Underlying Morphology," *The Journal of the American Medical Association*, March 4, 1933, Vol. 100, pp. 648-651; "Fallacies of the Senses," to be published in a forthcoming issue of *"Scientia"*; "Behavior Mechanisms and their Phylopathology," *The Psychoanalytic Review*, April 1935.

[28] In the experiments on animals performed by Pavlov and his school, (Pavlov, Ivan P., *Lectures on Controlled Reflexes, Twenty-five Years of Objective Study of the Higher Nervous Activity (Behavior) of Animals.* With an Introduction by Professor W. B. Cannon. International Publs., New York) certain conditioned differential reflexes were induced in response to quantitatively differing stimuli. Taking, for example, two tones of different vibration rates, as long as the animal sensed the two tones as discrete from one another the corresponding reflex reactions were carried out uniformly. But with the gradual approximation of the two tones to a more nearly equal vibration-rate a point was reached where the behavior of the animal became completely disorganized. The organism throughout became excited, irritable and generally distrait. Pavlov characterized this disintegrative behavior in the animal as "neurotic."

According to our experiments in phylopathology, the relation between the two differential reaction-systems existing in the human organism represents an analogy to the situation described in Pavlov's experiments. As long as these two systems remain discrete from one another, the organism's responses to stimuli are performed without difficulty. But with the encroachment of reactions proper to the partitive (graphonomic) system upon the function of the total-reaction system (stereonomic) there occurs a disparity in physiological patterns. This disparity in internal reaction-patterns causes a functional conflict within the organism. The disparity, however, as it occurs in the human organism represents not only a disturbance within the individual but, involving as it does a complex of stimuli which are phylogenetically integrated, there results a functional conflict the manifestations of which appear also within the organization of society as a whole.

It would appear, then, that there are in man extremely significant biological functions and alterations which are basic in the regulation and adjustment of the organism, but which are not observable through the avenues of the external senses. Though these processes are definitely accessible to objective study and control, they do not come within the category of phenomena ordinarily observable objectively through the avenues of the mental image or the idea. They are functions and alterations which do not belong to the sphere of the image or the idea as projected by the exteroceptive senses but to those functional configurations that affect man's internal environment, and that are therefore perceptible only in the measure in which the individual becomes the inside proprietor of his own organic processes.[29]

On this basis all the mental symptoms of conflict and disorder with their accompanying affect, as observable in the neurotic patient, are sensed as purely epiphenomenal manifestations—as being but external reflections of an actual morphological condition existing internal to the organism. In accordance, therefore, with the study of the total physiological organism in relation to the environment, it is not in the artificial amalgamation of the idea and the affect that the meaning of man's conflict, either individual or social, is to be found. This conflict is to be found in the body's internal structures, in which the function of the symbolic or graphonomic system on the one hand and that of the total stereonomic system of neuromuscular alterations on the other have

[29] An interesting study by Gustav Bally ("Biologische Voraussetzungen der frühkindlichen Persönlichkeitsentwicklung," *Schweizer Archiv f. Neurologie und Psychiatrie,* XXXII, 1, 1-6.) describes the early discrepancies in adaptation encountered by the infant. There are the instinctual, sensori-motor (animalic) promptings towards self-maintenance on the one hand and on the other the protective ministrations of the mother. The author presents the situation in very clear, biological terms, but this conflict between total animalic drives and those provisions of adaptation which are secured through the extraneous mediation of the parent has been recounted again and again by various writers and in various terms. What would seem required now is that this conflict that has been so well described receive some internal appreciation by us, that as organisms internally affected by the conditions we have described we now give to them a direct subjective application. We are not dealing with an extraneous phenomenon—not with some remote, external, projectively looked-at process—but with a condition that is subjective and inherent within the organism whose problem it is to locate and define this condition within itself in terms of intrinsic, physiologically controlled reactions.

See also paper by the same author, "Die frühkindliche Motorik im Vergleich mit der Motorik der Tiere," *Imago,* XIX, 1933, No. 3, pp. 339-366.

become artificially anastomosed. In brief, it is in man's physiology—internal and peripheral—that there is to be found the material to be observed and adjusted in face of those processes of man's behavior we see reflected outwardly in mental and emotional conflict.[30]

If, from a bio-physical basis of inquiry, it turns out that what we have been calling a conflict involving images and ideas is, in truth, a conflict within the behavior of the total physiological organism; if the apparent mental conflict is really an interference of neuromuscular patterns of response due to a confusion in man's attentional processes and if this conflict involves the crossing of neural impulses internal to the organism, we are, as often elsewhere in the fields of science, compelled to take fresh soundings. Our psychic and symbolic interpretations of individual and social maladjustments unquestionably possess the merit of serving as momentary palliatives and maintaining a certain peace or temporary restraint in the midst of a world of insanity and crime. But, if we are to establish in the field of human adaptation a unitary principle of interpretation comparable to the principles prevailing in other fields of medicine, we are compelled to relinquish our present external, symbolic interpretations in the sphere of man's adaptive disorders and instead to adopt a programme of revaluation that will better accommodate itself to more objective structural realities.

[30] As long as medicine, and therefore the community, holds to an interpretation of insanity that is based upon images and ideas, the care and treatment of the individual insane must be directed toward a programme of mental hygiene that can only encourage the patient to accommodate himself to the habitual community norm of adaptation, that is, to the wholly unstabilized, unscientific norm represented in the arbitrary "social images" which now characterize human adaptation on every hand. In repudiating, however, the customary mental interpretation of man's maladaptations of behavior as resting upon mere outer symptoms and appearances, we cannot repudiate the immense debt that is due psychiatry for the patient consideration it has devoted to these highly indicative symptomatic aspects of insanity, notwithstanding that in our characteristic mental interpretation of the functional insanities and neuroses, we who are psychiatrists are vainly laboring within and under the spell of the habitual mental restrictions of society itself. As a consequence it is little realized how impossible is the burden that is now placed upon psychiatrists year after year by the social community through its ever increasing demand for the care of patients on the basis of their own quite arbitrary, symptomatic interpretation of their disorders. Because of the objective and phyletic nature of the disorder calling for treatment, the response of psychiatry can necessarily continue to be only a tentative one in the absence of its recognition of the biological basis of these outer, symptomatic manifestations.

ON THE COMPARISON OF GROUPS IN RESPECT OF A NUMBER OF MEASURED CHARACTERS[1]

BY RAYMOND PEARL AND JOHN R. MINER

I

TO DETERMINE whether the means of a given character in two populations (groups) are significantly differentiated one can compare the difference of the means with the standard error of the difference. In other words if m_s, σ_s, and n_s are the mean, standard deviation and number of individuals measured for the sth character of the first population and m'_s, σ'_s, and n'_s the corresponding quantities for the second population we determine the probability that the universes from which these two samples are drawn differ in the mean of the sth character from the ratio

$$X_s = \frac{m_s - m'_s}{\sqrt{\frac{\sigma_s^2}{n_s} + \frac{\sigma'^2_s}{n'_s}}} \qquad \text{(i)}$$

This is sometimes called the critical ratio.

There are, however, occasions when one wishes some single measure of the degree of resemblance or divergence between a number of characters of two populations (groups). In 1921 Karl Pearson, in a paper by Tildesley,[2] proposed such a measure which he named the coefficient of racial likeness (C. R. L.). This was dealt with further in a later paper [3] and has been used in a number of craniometric papers published by members of the Biometric Laboratory of University College. If the

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[1] From the Department of Biology of the School of Hygiene and Public Health of the Johns Hopkins University.

[2] Tildesley, M. L. A first study of the Burmese skull. *Biometrika*, Vol. 13, pp. 176-262, 1920-21.

[3] Pearson, Karl. On the coefficient of racial likeness. *Biometrika*, Vol. 18, pp. 105-117, 1926.

two populations with which we are dealing are really samples from the same universe, the mean value of $m_s - m'_s$ will be zero and similarly for the other characters. Moreover, the distribution of differences of means will be close to a normal curve, especially if the original population is approximately normal, as is the case for most anthropometric measurements. The standard deviation in each series like $m_s - m'_s$ will be

$$\sqrt{\frac{\sigma_s^2}{n_s} + \frac{\sigma'^2_s}{n'_s}}$$

By dividing by the standard deviations we reduce the distributions of differences of means of the various characters to the same scale. In other words the critical ratio of each character considered varies about the origin of a normal curve with standard deviation unity. If we are dealing with M uncorrelated characters the expression

$$\frac{1}{M} S \left\{ \frac{(m_s - m'_s)^2}{\frac{\sigma_s^2}{n_s} + \frac{\sigma'^2_s}{n'_s}} \right\}$$

should within the error of random sampling approach the value unity. Therefore Pearson took as his coefficient of racial likeness

$$\text{C.R.L.} = \frac{1}{M} S \left\{ \frac{(m_s - m'_s)^2}{\frac{\sigma_s^2}{n_s} + \frac{\sigma'^2_s}{n'_s}} \right\} - 1 \pm 0.67449 \sqrt{\frac{2}{M}} \qquad \text{(ii)}$$

It is thus apparent that the coefficient of racial likeness is the mean value (minus 1) of the squared difference between the means of a series of characters in the two samples, the differences being reduced to relative terms by expressing them in units of their own standard deviations.

II

The probable error in (ii) measures the probability that the two groups are samples from the same population, i.e. that the deviation of the C. R. L. from zero is due merely to fluctuations of sampling. In this case the mean of X_s is zero and the C. R. L. is their variance (squared standard deviation) minus a constant, of the X_s's. Student's [4] distribution of the variance of samples drawn from a normal population therefore applies. But we may have two C. R. L.'s which are signifi-

[4] Student. The probable error of a mean. *Biometrika*, Vol. 6, pp. 1-25, 1908.

cantly different from zero and may wish to determine whether they are significantly different from each other, i.e., whether one pair of populations is more unlike than the other pair. In this case the mean of X_s is not zero and our sampling distribution is no longer that of the variance—the second moment measured from the mean—but of the second moment from a fixed origin.

Let ν_2 be the second moment measured from $X_s = 0$ of a sample of $X_1, X_2 \ldots X_s \ldots X_M$. Let $\overline{X}$ be the mean of the X_s's in the universe from which samples are taken and $x_s = X_s - \overline{X}$. Then

$$\nu_2 = \frac{S(X_s)^2}{M} = \frac{S(x_s+\overline{X})^2}{M} = \frac{S(x_s^2)}{M} + \frac{2\overline{X}S(x_s)}{M} + \overline{X}^2 \qquad \text{(iii)}$$

Summing for all samples and dividing by the number of samples we get the mean value of ν_2.

$$\bar{\nu}_2 = \mu_2 + \overline{X}^2$$

where μ_2 is the variance of the universe. Since x_1, x_2, etc., are not correlated and the distribution is normal, products involving odd powers of x_s vanish on summation.

$$\nu_2^2 = \left\{\frac{S(X_s)^2}{M}\right\}^2 = \left\{\frac{S(x_s+\overline{X})^2}{M}\right\}^2 = \left\{\frac{S(x_s^2)}{M} + \frac{2\overline{X}S(x_s)}{M} + \overline{X}^2\right\}^2$$

$$= \frac{\{S(x_s^2)\}^2}{M^2} + \frac{2\overline{X}^2S(x_s^2)}{M} + \frac{4\overline{X}^2\{S(x_s)\}^2}{M^2} + \overline{X}^4$$

+ terms in odd powers of x_s, etc., which vanish on summation

$$= \frac{S(x_s^4)}{M^2} + \frac{2S(x_s^2x_{s'}^2)}{M^2} + \frac{2\overline{X}^2S(x_s^2)}{M} + \frac{4\overline{X}^2S(x_s^2)}{M^2} + \overline{X}^4$$

+ terms in odd powers of x_s, etc., which vanish on summation.

Let N'_2 be the second moment of the distribution of ν_2 about $\nu_2 = 0$. $S(x_s^4)$ and $S(x_s^2)$ have M terms while $S(x_s^2 x_{s'}^2)$ has $\frac{1}{2}M(M-1)$ terms; therefore summing for all samples and dividing by the number of samples

$$N'_2 = \frac{\mu_4}{M} + \frac{\mu_2^2(M-1)}{M} + 2\overline{X}^2\mu_2 + \frac{4\overline{X}^2\mu_2}{M} + \overline{X}^4 \qquad \text{(iv)}$$

But, since the distribution is normal, $\mu_4 = 3\mu_2^2$; therefore

$$N'_2 = \mu_2^2\frac{(M+2)}{M} + 2\overline{X}^2\mu_2 + \frac{4\overline{X}^2\mu_2}{M} + \overline{X}^4$$

$$N_2 = N_2' - \bar{\nu}_2^2 = N_2' - \mu_2^2 - 2\overline{X}^2\mu_2 - \overline{X}^4 = \frac{2\mu_2^2}{M} + \frac{4\overline{X}^2\mu_2}{M} \qquad \text{(v)}$$

But $\mu_2 = 1$; therefore the probable error of C. R. L. in samples from a universe in which the mean of the X_s's is $\overline{X}$ is

$$\text{P.E.}_{(\bar{\varepsilon})} = 0.67449\sqrt{\frac{2 + 4\overline{X}^2}{M}} \qquad \text{(vi)}$$

III

The effect of the n_s and n'_s in (ii) is that as the size of the two samples considered grows larger the C. R. L. also increases, or, in other words, the probability that they are samples from the same universe decreases. From the probability standpoint this is as it should be. The probability that the means of two samples from the same universe shall diverge from each other by a given amount decreases as the size of sample increases. But viewing the C. R. L. as a measure of likeness or unlikeness between populations this is not so desirable a feature. Pearson [5] therefore proposed to reduce the coefficient to a standard sample by multiplying by

$$\frac{N^2}{2N} \times \frac{\bar{n} + \bar{n}'}{\bar{n}\bar{n}'}$$

where N is the standard size of sample and $\bar{n}$ and $\bar{n}'$ are the means of the n_s's and n'_s's respectively. For a standard sample of 100, which is usually taken, the correction factor becomes

$$50 \times \frac{\bar{n} + \bar{n}'}{\bar{n}\bar{n}'}$$

IV

Now it is evident that there is nothing in the derivation of the C.R.L. which will restrict it, as the name might seem to imply, to the comparison of different races. It may be used to measure the likeness or divergence of the means of the bodily measurements of any two groups, for instance of persons suffering from a given disease and persons not so suffering.

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[5] Pearson, Karl. Note on standardisation of method of using the coefficient of racial likeness. *Biometrika*, Vol. 20B, pp. 376-378, 1928.

Furthermore, it is to be noted that in all discussions of the C. R. L. up to this point it is tacitly assumed that statistically significant divergences between the means (or types) of characters in different groups are alone and in themselves sufficient to establish a generalization of true biological differentiation between the groups. But this is plainly a somewhat narrow and inadequate view of the matter, because clearly variabilities, for example, are just as truly and significantly statistical descriptive constants of groups as are means.[6] Two groups may be substantially identical in respect of means of a series of characters, and at the same time differ significantly in respect of both absolute (standard deviations) and relative (coefficients of variation) variabilities of the same characters. Conversely two groups may be substantially identical in variability and differ in their means. Anything that is to be regarded, overtly or tacitly, as a generalized statistical *description of a group* must take into account at least variabilities as well as types.

We therefore propose to extend the C. R. L. concept to include absolute and relative variabilities along with means in reaching a sound general appraisal of the divergence of any two groups in respect of a series of measured characters. This will necessitate an extension of terminology. While extending the terminology we venture also slightly to modify it, with the thought that amongst biologists, at least, the emphasis in thinking of group comparisons is apt to be rather more upon divergences than upon likenesses. We therefore propose to use in our work the three following coefficients:

1. Coefficient of Group Divergence in respect of Type, as measured by means (C. G. D. T.)
   (This is the same as Pearson's C. R. L. as given in (ii) *supra*)
2. Coefficient of Group Divergence in respect of absolute variability, as measured by the Standard Deviation (C. G. D. S.)
3. Coefficient of Group Divergence in respect of relative variability, as measured by the Coefficient of Variation (C. G. D. V.)

By an extension of the same reasoning as that used to derive C. G. D. T. we have

$$\text{C.G.D.S.} = \frac{1}{M} S\left\{\frac{(\sigma_s - \sigma_s')^2}{\frac{\sigma_s^2}{2n} + \frac{\sigma_s'^2}{2n'}}\right\} - 1 \pm 0.67449\sqrt{\frac{2}{M}} \qquad \text{(vii)}$$

[6] For a general discussion of this point see Pearl, R. Modes of Research in Genetics. *New York* (Macmillan), 1915. Chaps. II and III.

$$\text{C.G.D.V.} = \frac{1}{M} S \left\{ \frac{(V_s - V_s')^2}{\frac{V_s^2\left[1+2\left(\frac{V_s}{100}\right)^2\right]}{2n} + \frac{V_s'^2\left[1+2\left(\frac{V_s'}{100}\right)^2\right]}{2n'}} \right\} - 1 \pm 0.67449\sqrt{\frac{2}{M}} \qquad \text{(viii)}$$

where V is the coefficient of variation.

In (vii) and (viii) the probable errors given measure the probabilities that the respective coefficients differ from zero only as the result of fluctuations of random sampling. To estimate the probability that two coefficients are significantly different from each other (vi) should be used.

V

Pearl and Ciocco[7] have recently published the biometric constants of somatic measurements and indices of two groups of white males, one showing clinical evidence of cardiac disease, the other not showing it. From these data we have computed the coefficients of Group Divergence described above. Table 1 gives a sample of the actual numerical work and methods involved. Table 2 summarizes the results.

From Table 2 we note the following points:

1. Whether we consider crude or standardized figures all the coefficients of group divergence except C. G. D. V. for the indices differ from zero by amounts more than 5 times the probable errors for samples from the same universe, and in most cases more than 10 times. The C. G. D. V. for indices is slightly less than 3 times its probable error for samples from the same universe and therefore can be considered only probably significant. So then it may be concluded that except in respect of relative variability of the indices used the group of cardiacs is definitely differentiated or divergent from the group of non-cardiacs in a considerable series of absolute somatological measurements and proportions as to type, and as to absolute and relative variability.

2. The divergence between these two groups (cardiacs and non-cardiacs) is greater in respect of variability (C. G. D. S. and C. G. D. V.) than in respect of type (C. G. D. T.) so far as concerns absolute bodily dimensions; but the opposite relation obtains so far as concerns indices. If all characters are taken together (absolute dimensions and

[7] Pearl, R., and Antonio Ciocco. Studies in constitution, II. Constitutional differences associated with diseases of the heart in white males. *Human Biology*, Vol. 6, pp. 650-713, 1934.

TABLE 1

Calculation of the Coefficient of Group Divergence for Means (Absolute Measurements) Data from Table 2 of Pearl and Ciocco

CHARACTER	MEANS m_s Cardiacs	MEANS m'_s Non-Cardiacs	$(m_s - m'_s)^2$	$\frac{\sigma_s^2}{n}$	$\frac{\sigma'^2_s}{n'}$	$\frac{\sigma_s^2}{n} + \frac{\sigma'^2_s}{n'}$	$\frac{(m_s - m'_s)^2}{\frac{\sigma_s^2}{n} + \frac{\sigma'^2_s}{n'}}$	X_s
Body wt.	70.95	64.59	40.4496	3.0210	2.0736	5.0946	7.94	2.82
Stature	169.11	170.50	1.9321	.5409	1.6200	2.1609	.89	.94
Ht. e.a.m.	155.78	157.10	1.7424	.5893	1.5771	2.1664	.80	.89
Ht. s. st.	138.42	139.60	1.3924	.4166	1.4011	1.8177	.77	.88
Ht. l.c.m.	109.49	110.16	.4489	.3372	.8756	1.2128	.37	.61
Ht. sitting ...	87.97	88.10	.0169	.1465	.4122	.5587	.03	.17
Trunk l.	56.45	56.09	.1296	.1337	.2577	.3914	.33	.57
Span	174.65	177.09	5.9536	.7686	2.0777	2.8463	2.09	1.45
Head l.	19.09	18.88	.0441	.0099	.0138	.0237	1.86	1.36
Head br.	14.62	14.64	.0004	.0072	.0116	.0188	.02	.14
Br. biac.	37.62	36.76	.7396	.1083	.2578	.3661	2.02	1.42
Br. biil.	29.42	28.55	.7569	.0394	.0721	.1115	6.79	2.61
Br. gr. hip ...	33.84	33.00	.7056	.0484	.0986	.1470	4.80	2.19
Chest dp.	21.80	20.52	1.6384	.0888	.0409	.1297	12.63	3.55
Girth head ...	56.52	55.72	.6400	.03561	.03809	.07370	8.68	2.95
Girth neck	37.21	36.20	1.0201	.1534	.0874	.2408	4.24	2.06
Girth chest ex.	91.98	88.30	13.5424	.9665	.6116	1.5781	8.58	2.93
Girth chest rest	94.34	90.30	16.3216	1.0221	.7224	1.7445	9.36	3.06
Girth chest insp.	98.13	94.90	10.4329	1.0070	.7081	1.7151	6.08	2.47
Girth umbil. ..	93.33	87.10	38.8129	.4892	1.7749	2.2641	17.14	4.14
Ear l.	6.93	6.77	.0256	.00276	.00583	.00859	2.98	1.73
Ear br.	3.34	3.38	.0016	.00165	.00353	.00518	.31	.56
							98.71	39.50

$M = 22$

C. G. D. $= 3.49 \pm .20$ (.55)

$\overline{X} = 1.80$

$\overline{X^2} = 3.24$

TABLE 2

Coefficients of Group Divergence Between White Male Cardiacs and Non-cardiacs *

CHARACTER SERIES	NUMBER OF CHARACTERS INVOLVED	C. G. D. T.	C. G. D. S.	C. G. D. V.
		A. Crude Coefficients		
Absolute measurements ...	22	3.49±.20(.55)	6.18±.20(.66)	4.62±.20(.62)
Indices	11	5.33±.29(1.01)	1.73±.29(.65)	0.86±.29(.57)
All characters	33	4.09±.17(.50)	4.70±.17(.48)	3.37±.17(.44)
		B. Coefficients Reduced to Standard Sample of 100		
Absolute measurements ...	22	5.54±.32(.87)	9.81±.32(1.05)	7.34±.32(.98)
Indices	11	8.50±.46(1.61)	2.76±.46(1.04)	1.37±.46(.91)
All characters	33	6.50±.27(.79)	7.47±.27(.76)	5.36±.27(.70)

* The figures directly after the ± signs are probable errors for samples from the same universe, those in parentheses are probable errors for samples from universes having the same X_s's as the observed populations.

indices) there appears to be about the same degree of divergence between the cardiac and non-cardiac groups in respect of type and variability, whether absolute or relative.

Pearson [8] considers that a C. R. L. of less than 1 indicates very intimate association of two races, between 1 and 4 close association, between 4 and 7 moderate association, between 7 and 10 slight association, between 10 and 13 doubtful association, while a C. R. L. over 13 indicates divergence of the races. Even on this somewhat arbitrary basis we see from Table 1 that our two groups, each composed of males of European origin, and differentiated from each other not on racial grounds but on the basis of their pathology, show C. G. D. S. that indicate generally slight association. In other words, not only is it highly improbable that the cardiacs and non-cardiacs are samples from the same population—except in the case of the C. G. D. V. for indices—but the differentiation of the two groups is of the same order of magnitude as that between such races as Anglo-Saxons and Prehistoric Swedes.[8]

[8] Morant, G. M. A preliminary classification of European races based on cranial measurements. *Biometrika*, Vol. 20B, pp. 301-375, 1928.

VI

As has been pointed out above Pearson has stated that the whole derivation of the C. R. L. assumes that the characters, whose squared differences (in relative units) between means are averaged to get the coefficient, are uncorrelated. This assumption is, of course, contrary to reality whenever any more than two or three characters are enfolded in the coefficient. All biometric experience teaches that *some* degree of correlation exists between most measurable characters of organisms. In fact this general integrative correlation between their parts is one of the most striking and important characteristics of organisms as such.

What has actually happened in the use of the C. R. L. by Pearson and his associates in craniometric work is that in practice the effect, if any, of the existing cranial correlation upon the coefficient of racial likeness has been neglected. The actual procedure has been *as if* all the correlations were zero. But by no means all the characters used in craniometric appraisals of racial likeness or divergence have even low correlations. Thus Morant[9] gives in his Table I a standard list of cranial characters which has been generally followed by those using the C. R. L. The correlations for a number of these characters have been given by Pearson and Davin[10] in their Table V for Egyptians of the XXVI-XXX Dynasties. The frequency distribution for the male correlations is as follows:

Class limits *	*Frequency*
0-.09	34
.10-.19	19
.20-.29	19
.30-.39	9
.40-.49	14
.50-.59	4
.60-.69	8
.70-.79	6
.80-.89	2
	115

* Positive and negative correlations.

[9] Morant, G. M. A study of certain oriental series of crania including the Nepalese and Tibetan series in the British Museum (Natural History). *Biometrika*, Vol. 16, pp. 1-105, 1924.

[10] Pearson, Karl, and Adelaide G. Davin. On the biometric constants of the human skull. *Biometrika*, Vol. 16, pp. 328-363, 1924.

The mean of this distribution is .281 ± .014 and it will be seen that some of the correlations are quite high.

What effect will the neglect of these correlations have? Pearson [3] has suggested an alternative method which takes account of the correlations. If we form the determinant

$$R = \begin{vmatrix} 1, & r_{12}, & \ldots & r_{1M} \\ r_{21}, & 1, & \ldots & r_{2M} \\ \ldots & \ldots & \ldots & \ldots \\ r_{M1}, & r_{M2}, & \ldots & 1 \end{vmatrix}$$

and its minors, R_{ss}, R_{st}, etc.

$$\chi^2 = \frac{1}{R}\left\{\sum_{1}^{M}(R_{ss}X_s^2) + 2S'(R_{st}X_sX_t)\right\} \qquad \text{(ix)}$$

If all the correlations between the characters dealt with are zero, R and the various R_{ss}'s equal unity while the various R_{st}'s equal zero. Equation (ix) therefore reduces in this case to

$$\chi^2 = S(X_s^2) \qquad \text{(ix bis)}$$

In other words, when the correlations between the characters are zero

$$\text{C. R. L.} = \frac{\chi^2}{M} - 1 \qquad \text{(x)}$$

So then it would logically follow that the amount by which in a given case C. R. L. computed from (ii) differs from C. R. L. computed from (x) represents the resultant effect of the correlations neglected in (ii). Pearson has pointed out that for any considerable number of characters the arithmetical labor of computing the determinants is prohibitive. We have accordingly picked out the four most highly correlated characters—Body weight, Chest girth (resting), Chest girth (inspiration), and Chest girth (expiration)—from the unpublished correlations of measurements of cardiacs computed by Dr. Antonio Ciocco [11] in this laboratory as a first test of the above method. In applying the test we are assuming that all we know about the two groups, cardiacs and non-cardiacs, are the means, standard deviations and intercorrelations

[11] To whom we are greatly indebted for his kindness in permitting us to use the correlation data, computed at the expense of much tedious labor on his part, in advance of their publication.

of the four named characters, and that the correlations are not significantly different in the two groups.

We then reach the following results:

1. C.R.L = 6.99 ± .48 (1.96) by equation (ii)—i.e. by direct computation from observed means and standard deviations, *neglecting* the correlations.

2. The six possible zero-order correlations between the four characters named, as actually observed, range between +.921 to +.991, with a mean value for the six of +.956. These are indubitably high correlations.

3. $\chi^2 = 1988$ from (ix), whence C.R.L. = 496, from (x).

With these results in hand we then proceeded to a second test by adding to the four characters a fifth, namely Stature, with the same assumptions as before *mutatis mutandis*. The results then were:

1. C.R.L. = 5.57 ± .43(1.31) by equation (ii). It is plain that this value does not significantly differ from the 6.99 of the first test.

2. Putting stature into the system adds four new correlations. The observed values of these range between +.128 and +.196, and the mean value of the 10 possible inter-correlations for all five characters is +.634, a considerable reduction from the +.956 of the first test.

3. $\chi^2 = 2008$ from (ix), whence C.R.L. = 400.6 from (x).

Let us now set up the following simple proportion

$$5.57 : 400.6 :: 6.99 : x.$$

Solving, $x = 502.7$. This differs from the observed 496 by only 6.7, an error of 1.35 per cent. In other words it appears clear that so far as concerns these two examples no difference is made in any practical conclusion as to the relative degree of "racial likeness" between the two groups compared if one takes account of correlations or does not.

But a mean value of the correlations of +.634 represents, after all, a substantial degree of correlation in the system, certainly far removed from no correlation at all. Therefore we are led to a third test. For this we have chosen three characters but slightly inter-correlated, viz. Sitting Height, Head Breadth, and Neck Girth. The results are:

1. C.R.L. = 0.45 ± .55 (.71) by equation (ii).

2. The three possible inter-correlations have values of —.019, —.024, and +.055, giving a mean numerical value disregarding signs of .033. The mean value having regard to signs is +.004. In other words the correlations in this example closely approach zero.

3. $\chi^2 = 4.29$ from (ix), whence C.R.L. = .43 from (x). This value is substantially identical with that from (ii) given above.

From these examples we conclude that the only *practical* effect upon coefficients of group divergence of taking account of the inter-correlations of the characters entering into the coefficients by the method proposed by Pearson [3] will be to alter the *absolute scale* of numerical magnitudes of the coefficients, without essentially altering their proportions one to another. In other words no biological conclusion capable of being drawn from an examination of C. G. D.s seems likely to be changed if the coefficients are, or are not, corrected by the application of Pearson's method to take account of correlations, save possibly in one respect to be mentioned presently. This result is, in our opinion, one to be expected *a priori* for two reasons. In the first place the elementary theory of correlation makes it plain the value of r in a bivariate distribution has nothing whatever to do with the value of the means of the marginal total arrays of that distribution, and it is with differences between marginal total arrays alone that C. R. L.s and C. G. D.s have to do. In the second place if it be argued, as it justly may be, that in sets of characters sensibly correlated *inter se* the number of *independent* differences entering into the mean value that is the coefficient tends to be reduced in proportion to the magnitude of the correlations (ultimately to one difference as the limit when every $r = 1$) this condition is, after all, a fact of nature not capable of being altered by any sort of purely mathematical manipulation. In short if two groups are really different in the mean absolute magnitudes of their characters, they will still be different if those characters are highly correlated *inter se* or are not correlated with each other at all. And similarly if the groups are really not different, inter-correlation of characters within each group is not going to make them different.

Leaving the discussion of the coefficients themselves regarding which the practical conclusion is that, since only a scale alteration results from taking correlations into account by the Pearson method, correlations may be safely neglected, it needs to be pointed out that the same will not hold true for the probable errors of the coefficients. The reason for this is that, in simplest terms, the scale alteration of the probable errors will not necessarily be the same as that of the coefficients themselves, because the higher power cross product terms in deriving the probable error will not vanish. Whether the difference in scale alterations for coefficients and their probable errors will be great enough to be of practical moment has not been investigated.

We hope in a later paper to return to this particular problem, in connection with a further investigation of the relation of correlation to coefficients of group divergence. Pearson's method of dealing with correlations discussed in this paper assumes that the inter-correlations between the M characters are identical (save for fluctuations of random sampling) in the two compared groups (races, populations, etc.). In fact the determinant leading to (ix) in its present form is incapable of dealing with a situation where the correlations are different in the two compared groups. We understand and have no criticism of this assumption as a practical statistical expedient in the early development of the subject. But we are, however, of the opinion that correlations of characters *inter se* constitute just as important a part of the complete biometric description of groups as do means and variabilities. C. G. D.s for correlation coefficients may be set up just as those for means and variabilities have been. This we propose later to do. It seems to us that in any logically complete theory of C. G. D.s any *differences* of correlation in the two groups should be taken into account. This may require a wholly different approach than any yet made. One obvious suggestion is that instead of taking the unweighted means of differences as the coefficient a mean weighted inversely as the average correlation of the character concerned with all other characters in the system might be taken. How this would work we do not know, but as has already been said, we hope to deal generally with the subject in a later paper.

In concluding we wish to express our thanks to Dr. Lowell J. Reed for helpfully discussing the problem with us during the progress of the work.

BONE WEIGHT IN THE HUMAN CARPUS

BY S. IDELL PYLE*

The Samuel S. Fels Fund for Research in Prenatal and Postnatal Environment

IN HIS recent analysis of bone weight for 100 skeletons between nineteen and seventy-eight years of age, Ingalls(3) has given values for summated weight for the right carpus, metacarpus, phalanges, and hand, and for the left hand. He found that 82 per cent of the right hands were heavier than the left. He points out that the left side of the body tends to be less stable in skeletal weight than does the right, and calls attention to the fact that the peripheral portion of the upper limb is most asymmetrical.

During the course of an investigation of bone form in young adults, the bones in the carpus were weighed in order to supplement Ingalls' findings. While the material represented a collection made over a period of fifteen years, the maceration and drying had been done under similar conditions and therefore it seems to be an unusually uniform sampling of dried bone. The weights were made on an analytical balance, and were recorded to the nearest 10 milligram value. Hands of sixty-four male whites from nineteen to thirty-two years inclusive were used. The mean age was $26.7 \pm .29$ years with a standard deviation of 3.39 years. This age span just preceded the lustrum at which Ingalls found maximum bone weight was attained, namely thirty to thirty-five years.

The findings given in Table 1 confirm his conclusions regarding differences between the right and left hand. His value was $68.7 \pm .81$ grams total weight for the right hand and the mean for this group was $61.4 \pm .998$ grams. The difference between the means is significant. However, his value of $65.6 \pm .76$ grams for left hand was also greater than the value for this group, the difference was significant, and showed that the mean weight for this group was less than the mean weight for the group which he investigated.

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TABLE 1

Weight of the Left Carpus

CARPAL	NUMBER	MEAN *Grams*	STANDARD DEVIATION	COEFFICIENT OF VARIABILITY	RANGE	
					Minimum	Maximum
Navicular	63	2.23±.04	0.53±.03	23.76±1.52	1.27	3.56
Lunate	64	1.69±.03	0.39±.02	23.02±1.44	0.91	2.54
Triquetral	64	1.18±.02	0.29±.02	24.24±1.51	0.45	1.90
Greater Multangular	63	1.65±.03	0.40±.02	24.06±1.52	0.94	2.75
Lesser Multangular	64	1.14±.02	0.28±.02	24.82±1.58	0.62	2.00
Capitate	64	2.72±.05	0.64±.04	23.64±1.51	1.15	4.60
Hamate	64	2.21±.04	0.48±.03	21.76±1.40	1.23	3.55
Pisiform	61	0.61±.01	0.17±.01	27.37±1.84	0.24	1.04
Total Carpals	57	13.56±.22	2.59±.16	19.02±1.24	7.86	19.01
Metacarpal I	64	4.66±.07	0.87±.05	18.61±1.17	3.00	6.97
Metacarpal II	64	7.12±.11	1.32±.08	18.51±1.17	4.70	10.22
Metacarpal III	64	6.67±.11	1.26±.08	18.82±1.17	4.40	9.50
Metacarpal IV	64	4.06±.07	0.78±.05	19.31±1.17	2.47	5.70
Metacarpal V	64	3.47±.06	0.67±.04	19.37±1.17	2.23	4.87
Total Metacarpals	57	25.99±.39	4.42±.28	17.01±1.10	18.05	33.32
Proximal Phalanx I	51	2.27±.04	0.41±.03	18.06±1.24	1.37	3.25
Proximal Phalanx II	51	3.22±.06	0.59±.04	18.26±1.24	2.15	4.49
Proximal Phalanx III	51	4.02±.07	0.76±.05	18.93±1.31	2.62	5.35
Proximal Phalanx IV	51	3.07±.05	0.57±.04	18.44±1.24	1.89	4.19
Proximal Phalanx V	51	1.87±.03	0.35±.02	18.56±1.31	1.07	2.69
Total Proximal Phalanges	51	14.42±.25	2.67±.18	18.38±1.24	9.60	19.73
Middle Phalanx II	51	1.22±.02	0.26±.02	20.98±1.46	0.72	1.72
Middle Phalanx III	51	1.82±.04	0.38±.03	21.04±1.46	1.00	2.47
Middle Phalanx IV	51	1.47±.03	0.30±.02	20.41±1.39	0.75	2.10
Middle Phalanx V	51	0.75±.02	0.16±.01	21.22±1.46	0.37	1.15
Total Middle Phalanges	51	5.27±.01	1.07±.07	20.30±1.39	3.11	7.42
Distal Phalanx I	51	0.88±.02	0.20±.01	22.15±1.46	0.61	1.34
Distal Phalanx II	51	0.46±.01	0.12±.01	25.00±1.77	0.27	0.64
Distal Phalanx III	51	0.50±.01	0.13±.01	25.20±1.77	0.29	0.76
Distal Phalanx IV	51	0.40±.01	0.09±.01	22.83±1.62	0.25	0.57
Distal Phalanx V	51	0.31±.003	0.03±.002	10.65±0.74	0.18	0.45
Total Distal Phalanges	51	2.55±.24	0.53±.04	20.78±1.46	1.71	3.58
Total Phalanges	51	22.32±.41	4.66±.31	20.88±1.46	14.86	30.62
Total Carpus	48	61.38±.99	10.25±.71	16.70±1.20	41.79	83.71

Although these bones were only 92 per cent as variable as Ingalls' selection, the difference between the coefficients of variability was not mathematically significant. But when the difference between standard deviations for the two groups was also considered, the results showed that Ingalls' group was the more variable. This is in accord with the conclusions which both Todd and Ingalls have reached regarding the effects of age upon bone structure as shown by the Hamann Museum skeletons.

In order of variability in weight the elements of the hand ranked thus: carpals, distal phalanges, middle phalanges, proximal phalanges, metacarpals, the last element being the least variable. The sesamoid element pisiform was the most variable, and the distal phalanx of the fifth metacarpal was the least. The size of the bone was not the factor which determined variability.

The bones were distributed as follows according to their weight:

Metacarpal II
Metacarpal III
Metacarpal I
Metacarpal IV
Proximal Phalanx III
Metacarpal V
Proximal Phalanx II
Proximal Phalanx IV
Capitate
Proximal Phalanx I
Navicular
Hamate
Proximal Phalanx V
Middle Phalanx III
Lunate
Greater Multangular
Middle Phalanx IV
Middle Phalanx II
Triquetral
Lesser Multangular
Distal Phalanx I
Middle Phalanx V
Pisiform
Distal Phalanx III
Distal Phalanx II
Distal Phalanx IV
Distal Phalanx V

Table 1 demonstrates the variations in weight for different parts of the hand skeleton. The carpus is the most variable, the distal phalanges next most variable, followed by middle and proximal phalanges, with metacarpals the least variable.

WEIGHT OF THE CARPALS

Recently interest has been renewed in carpal relations because of the stress which has been laid upon this region as a criterion for skeletal growth.

Baldwin, Busby, and Garside (2) reviewed the literature on order of ossification and pointed out the erratic tendencies in initial ossification which all investigators have observed. They demonstrated that the variability in area of ossification decreases as the carpus matures.

Our variability in mature weight is greater than their variability in area. Before turning to the relation existing between weight and area, attention was centered upon weight itself. The total weight of the carpals was 13.6±.22 grams as compared with Ingalls' value of 15.3±.21 grams. The variability was 19.02 per cent as compared with his value of 21.09 per cent.

As one would predict from its size and shape the capitate is the heaviest carpal. The hamate and navicular are next heaviest, are significantly lighter than capitate, and are almost equal in mean weight. The difference between the mean weights of lunate and greater multangular is very slight and not at all significant. Triquetral and lesser multangular follow next in order with pisiform the lightest element.

Except for the navicular and the triquetral, the relative ranking in mature weight is the same as the order in which the initial ossification centers make their postnatal appearance.

Specific relations in weight were tested further by correlating individual weights by the method of rank differences and translating them into the corresponding product-moment values. The correlation values showed whether the various bones in the same hand weighed relatively the same, and also showed which bones were most similar in relative weight.

A fairly close relationship exists between the weights of the bones in the true carpus. The pisiform was least closely related to the other seven bones, but it is usually not described as a true carpal element.

The closest relationships existed between the capitate and hamate, and the capitate and lesser multangular. In general, the triquetral was least closely related to the other carpals. The distal row was significantly more closely interrelated than was the proximal row, and the triquetral was least in agreement in weight-rank with the distal row.

There is some evidence that adjacent bones are most closely interrelated in weight. The following summary shows the interrelations:

Carpal	*Most Closely Related*	*Least Closely Related*
Greater Multangular	Lesser Multangular	Triquetral
Lesser Multangular	Capitate	Triquetral
Capitate	Hamate and Lesser Multangular	Triquetral
Hamate	Capitate	Triquetral
Navicular	Lesser Multangular	Triquetral
Lunate	Capitate and Hamate	Greater Multangular
Triquetral	Hamate	Navicular
Pisiform	Triquetral	Lesser Multangular

These interrelations suggest the possibility that the distribution of the blood supply to the carpals may be one factor in producing such relationships. Experiments on bone repair have shown the marked effects of modifications in blood supply. So far the investigator has not been able to find any information on the precise distribution of the blood supply to the individual carpals themselves. Adachi (1) in his extensive investigation on the distribution of the arteries demonstrated that the deep volar arch is made up largely from the ulnar artery. Since the triquetral and pisiform are more superficial, do they tend to have a common blood supply which does not come from the deep arch? Does this account for the fact that they are more variable in weight than are the adjacent carpals?

The effects of position and function in the hand are more apparent than that of blood supply. The distal row is very compact with little intervening cartilage, while the proximal row is separated by heavy cartilaginous plates.

The closer analogy in weight in the distal row may be allied with their similarity in function, while the manner in which the proximal row adapts to movements of the radius upon it may modify its structure, and therefore its weight.

Carpals	*r*	*P.E.*
Greater multangular and lesser multangular	+.88	± .02
Greater multangular and capitate	+.87	± .02
Greater multangular and hamate	+.79	± .02
Greater multangular and navicular	+.76	± .03
Greater multangular and lunate	+.76	± .04
Greater multangular and triquetral	+.74	± .04
Lesser multangular and capitate	+.89	± .02
Lesser multangular and hamate	+.85	± .02
Lesser multangular and navicular	+.84	± .03
Lesser multangular and lunate	+.77	± .04
Lesser multangular and triquetral	+.76	± .04
Hamate and capitate	+.89	± .02
Hamate and navicular	+.83	± .03
Navicular and capitate	+.85	± .03
Lunate and capitate	+.82	± .03
Lunate and hamate	+.82	± .03
Lunate and navicular	+.79	± .03
Lunate and triquetral	+.77	± .04
Triquetral and capitate	+.77	± .04
Triquetral and hamate	+.80	± .03
Triquetral and navicular	+.70	± .05
Pisiform and greater multangular	+.50	± .06
Pisiform and lesser multangular	+.43	± .07
Pisiform and capitate	+.53	± .06
Pisiform and hamate	+.56	± .06
Pisiform and navicular	+.47	± .07
Pisiform and lunate	+.48	± .07
Pisiform and triquetral	+.61	± .05

THE METACARPALS

The total weight for the metacarpals was 26.0±.39 grams. Ingalls' (3) values for the right hand exceeded this value, his being 28.3±.34 grams, and again the evidence points toward the effects of age upon bone weight. In one carpus the epiphyses were partially united to the diaphyses but the union was plainly incomplete.

There was not much difference between the weight of the second and third metacarpals. The fourth and fifth weigh about half as much as do the second and third.

Both Todd and Ingalls have shown various ways in which the metacarpals are less variable than the carpals. This was true of their weight.

The correlations in individual bones in the same hand tended to be more uniformly interrelated than did the weight of the carpals in the same hand. The relationships were as follows:

1st metacarpal and 2nd metacarpal	+.86 ± .02
1st metacarpal and 3rd metacarpal	+.81 ± .03
1st metacarpal and 4th metacarpal	+.80 ± .03
1st metacarpal and 5th metacarpal	+.81 ± .03
2nd metacarpal and 3rd metacarpal	+.90 ± .02
2nd metacarpal and 4th metacarpal	+.89 ± .02
2nd metacarpal and 5th metacarpal	+.90 ± .02
3rd metacarpal and 4th metacarpal	+.92 ± .01
3rd metacarpal and 5th metacarpal	+.93 ± .01
4th metacarpal and 5th metacarpal	+.90 ± .02

From the functional point of view this observation is what one might expect. The first and second metacarpals are closely correlated in weight, and the first is least related to the other four. A close relationship exists between the relative weights of the second, third, fourth, and fifth metacarpals.

THE PROXIMAL PHALANGES

Ingalls (3) did not give total values for each of the phalangeal units, but his mean value for total phalanges was 25.1±.30 grams as compared with the value of 22.3±.41 grams for these hands. This difference is relatively the same as the difference shown for other carpal elements. These proximal phalanges as well as those which Ingalls studied were less variable than were the metacarpals.

The correlations in weight were as follows:

1st and 2nd proximal phalanx	+.93 ± .01
1st and 3rd proximal phalanx	+.88 ± .02
1st and 4th proximal phalanx	+.84 ± .03
1st and 5th proximal phalanx	+.89 ± .02
2nd and 3rd proximal phalanx	+.93 ± .01
2nd and 4th proximal phalanx	+.95 ± .01
2nd and 5th proximal phalanx	+.90 ± .02
3rd and 4th proximal phalanx	+.95 ± .01
3rd and 5th proximal phalanx	+.93 ± .01
4th and 5th proximal phalanx	+.90 ± .02

The units are closely interrelated in relative weight. The calculations show that the first phalanx again tends to be least closely related to the others.

MIDDLE PHALANGES

In Table 1 the rise in the coefficient of variability is shown. The individual variabilities are interesting when one considers that it is usually somewhat difficult to distinguish the second unit from the fourth in the macerated carpus.

The interrelations as shown by the correlations were as follows:

2nd and 3rd middle phalanx	+.92 ± .02
2nd and 4th middle phalanx	+.86 ± .02
2nd and 5th middle phalanx	+.89 ± .02
3rd and 4th middle phalanx	+.91 ± .02
3rd and 5th middle phalanx	+.90 ± .02
4th and 5th middle phalanx	+.94 ± .01

The adjacent elements are seen to be most closely related in relative weight. Flexion and extension are the two movements executed upon these bony segments. One then speculates whether the closer relationship shown by adjacent elements is governed by similarity in use and wonders how bone can be modified in weight by the types of muscular forces acting upon it.

DISTAL PHALANGES

The coefficients of variability show that the distal phalanges are almost as variable in weight as are the carpals. The exception is the fifth and the striking results for it elude interpretation. A fellow worker who was examining the bones when they were assembled for weighing remarked about their monotonous similarity in form. The fact that the weight was corrected to the nearest 10 milligram value would smooth the results for smaller bones to a greater degree than for the larger.

The first, third, and fifth distal phalanges are most closely related in relative weight, and the second and fourth pair together.

1st and 2nd distal phalanx	+.81 ± .03
1st and 3rd distal phalanx	+.88 ± .02
1st and 4th distal phalanx	+.86 ± .03
1st and 5th distal phalanx	+.88 ± .02
2nd and 3rd distal phalanx	+.86 ± .03
2nd and 4th distal phalanx	+.70 ± .05
2nd and 5th distal phalanx	+.81 ± .03
3rd and 4th distal phalanx	+.80 ± .04
3rd and 5th distal phalanx	+.83 ± .03
4th and 5th distal phalanx	+.84 ± .03

The interrelations in relative weight are lower for this hand unit than for any other. Ingalls (3) brings out the point that the metacarpals appear to be more variable than the phalanges. Our results show that the reverse is true for this group. If age and function are modifying factors as he suggests (3, pp. 86-88), some light is thrown on the causes for the difference. He also showed that the left hand was less stable than the right. This point is of great interest because it invites analysis of the factors which govern form, structure, and function during the developmental stages, complex as that problem is.

GENERAL CONSIDERATIONS

Could these weights have been affected by the general physical condition of the individuals studied? It is remotely probable, since they were below the mean age for death for the general population. Tuberculosis was the cause of death in 37.5 per cent of the cases; one-fourth of them met death through accident or suicide. The majority of the rest died from diseases which terminate fatally within a short time as a rule.

They were of normal build judged by MacKinnon and Jackson's(4) values for the male students at the University of Minnesota. Their figures for 1205 students were 1744.5 mm. for mean length, and 141.1 pounds for mean weight. The mean length for this group was 1715.9 ± 5.98 mm. and mean weight was 141.5 ± 2.09 pounds.

In order to test some of the relationships existing between form and weight, correlations were made between the length of the hand and its weight, the weight of the hand and the weight of the body. The hand length used was the measurement made by Todd upon the fresh cadaver. This hand length is the projected distance between dactylion and radial stylion measured parallel with the axis of the third finger, this axis being continued in a straight line with that of the forearm.

The correlation between the length of the hand and the weight of the hand skeleton was $+.70 \pm .08$. This is higher than the correlation found between total body weight and total length which was $+.41 \pm .08$. This is not surprising, since the skeleton makes up the bulk of the hand structure, and the weight of soft parts must be extremely variable.

The correlation between the weight of the body and the weight of the hand was less, being $+.32 \pm .09$. Neither is the relationship be-

tween body length and hand length any closer, r being $+.32\pm.12$. These figures do not show that much relationship exists between size of the body and size of the hand.

Finally, a test was made of the relation existing between area and weight. For this the *os lunatum* was selected, because as will be shown in a forthcoming study the bone is of such configuration that seen from various aspects its area measured from roentgenograms made of the dissected bone does not vary much from the values given by Baldwin, Busby, and Garside on the living.

The correlation proved to be $+.55\pm.06$. It is seen that when surface area is taken into consideration, the relationship between size and weight is better expressed. There still remains to be considered the interesting features of density and volume which would doubtless clarify many points.

SUMMARY

1. The hand skeleton of sixty-four male whites between nineteen and thirty-two years inclusive was weighed. Although the individuals studied were below the mean age for death for the general population, they were not atypical in general build, judged by MacKinnon and Jackson's standards for students at the University of Minnesota.

2. The carpals are the most variable hand elements. There is some evidence that the bones which are heaviest at maturity acquire postnatal centers of ossification first. Adjacent bones are usually most closely interrelated in weight.

3. Contrary to Ingalls' findings the metacarpals are less variable in weight than are the phalanges in this group.

4. This sampling confirms Todd's and Ingalls' proof of effects of age upon skeletal structure and weight.

In conclusion I wish to express my indebtedness to Dr. T. Wingate Todd for the use of the material in Hamann Museum and for his stimulating interest and constructive comments on the findings. I also owe much to Dr. Ingalls for his criticism of the work at various stages in its completion, and for his suggestions regarding some comparisons which he had not made in his own monograph. Finally, no research involving great numbers of figures is completed without careful checking, and much credit is due to Mary K. Condon for her help on computations.

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NOTES

MARRIAGE HYGIENE: A SCIENTIFIC QUARTERLY

THIS new journal, the first number of which appeared in August, 1934, will carry general and special articles, in addition to abstracts of the world's scientific literature, on marriage, the family, eugenics and racial welfare, sexual or social hygiene, contraception, sterilization, and marital adjustment—in short, scientific material treating marriage as a social and biological institution. The field is thus medico-sociological.

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